EXHIBIT 43
[FILED UNDER SEAL]

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF TEXAS

SHERMAN DIVISION

The State of Texas, et. al. Plaintiff, v. Google LLC, Defendant.	Case No: 4:20-CV-957-SDJ

Rebuttal Expert Report of Anil Somayaji, PhD

Signed on September 9, 2024, in Nashville, Tennessee, USA

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Anil Somayaji, PhD

Table of Contents

I.   INTRODUCTION

A.   Assignment

1. I understand that on December 16, 2020, a multistate coalition led by the State of Texas filed a lawsuit against Google LLC ("Google") asserting violations by Google of federal and state antitrust laws and violations of other state laws, in connection with Google's conduct in the online display advertising industry and as to digital advertising technologies ("Ad Tech" or "Ad Tech stack"). Currently, 16 States (Texas, Alaska, Arkansas, Florida, Idaho, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nevada, North Dakota, South Carolina, South Dakota, and Utah) and the Territory of Puerto Rico are Plaintiffs in the case (the "Plaintiff States"). I have been retained by counsel for the State of Texas ("Counsel") to provide expert analysis and opinions on behalf of all of the Plaintiff States.

2. I have been asked by Counsel to respond to the opinion in Dr. Milgrom's expert report ("Milgrom Report") that advertisers and publishers are able to optimize their behavior in response to modifications that Google introduces to its auction programs.

3. To this end, I investigated whether there exists an information advantage for Google and users of its auction-based advertising tools over third-party buyers that distribute ads through Google's ad-serving infrastructure. More specifically, I examined the source code of Google's ad infrastructure, Google's internal documentation and correspondence that have been disclosed as part of these proceedings, as well as publicly available primary materials, all of which are listed in Appendices Appendix A: Materials Relied Upon - Appendix C: Source code appendix of this report. I have further considered the opening report and appendices Dr. Hochstetler and the rebuttal report of Dr. Rinard, and I considered the rebuttal report of Dr. Milgrom.

4. The opinions in this report are based on my research and experience in the field of secure, distributed software systems, and the materials briefed to me by Counsel. Additionally, I have also relied on my own experience in complex, distributed computer systems that I have developed through my research in computer security, complex systems, and my teaching of distributed operating systems. My opinion is based on my review of the source code and documents available

to me as of the time this report was published.[1] I further reserve the right to supplement my report should any additional information be produced in this case, as well as to create and use graphics, figures, and/or other illustrations at trial to support my conclusions.

5. I am being compensated for my work in this case at a rate of $600 per hour. My compensation does not depend on or affect the opinions that I offer.

6. I am competent to testify regarding the matters and opinions I present in this report. I further have personal knowledge of the facts and statements presented herein, and if asked could testify that each statement is true and correct.

B.   Qualifications

7. I am an Associate Professor in the School of Computer Science at Carleton University, in Ottawa, Canada. I also serve as the Associate Director of the Carleton Internet Security Lab. I received a B.S. in Mathematics from the Massachusetts Institute of Technology in 1994 and a Ph.D. in Computer Science from the University of New Mexico in 2002. While working on my Ph.D., I was a visiting graduate student at the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology between 1996 and 1997 and a Research Assistant at the University of New Mexico between 1995-2002. After graduating, I was a Postdoctoral scholar at the University of New Mexico, following which I worked as a Consultant for Sandia National Laboratories, before joining the faculty at the School of Computer Science at Carleton University. I have been a full-time university professor since 2003.

8. I have authored or co-authored over 50 publications across refereed conferences publications, peer-reviewed journal articles, and other invited publications and articles. My papers have appeared in leading academic journals, such as the Journal of Computer Security, the Journal of the Association for Computing Machinery (ACM), and the IEEE Transactions on Dependable and Secure Computing. Collectively, my papers have been cited over 10,000 times in published work. I have been part of many program committees in the computer security space. I have been most involved in the New Security Paradigms workshop, for which I have served as program committee chair, general chair, program committee member, and web chair over many years.

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[1] I understand that Google produced chat log data. I reserve the right to review and analyze such data and to serve a supplemental report in the future.

9. During my tenure at Carleton University, I have taught courses in operating systems, distributed operating systems, computer systems security, biological approaches to computer security, intrusion detection, web applications, mobile development, and computer games.

10. My academic research is focused on the areas of computer security, operating systems, intrusion detection, artificial life, and complex adaptive systems. My approach to research in computer security is fundamentally interdisciplinary, with my original efforts inspired by the human immune system where I have studied how to build a "computer immune system." More recently I have worked in usable security, a research area at the intersection of human-computer interaction (HCI) and computer security, where I have studied security in online dating and how people identify each other when texting. No matter the work, the core of my interests lies in understanding how systems of all kinds defend themselves and how those insights can help us build computers that defend themselves.

11. My background makes me particularly suited to addressing the question of Google's information advantage in ad distribution because:

   a) Through my work with developing defenses for the Linux kernel, mail servers, web servers, and other applications, I have significant experience in examining large codebases. Google's ad infrastructure is a very large codebase.

   b) Through my teaching courses in distributed operating systems over many years, I am familiar with many of the key systems and abstractions Google uses internally, as they have been described in highly cited research papers authored by Google's engineers and researchers.

   c) Through my work in online machine learning systems for detecting anomalous program and user behavior (a central part of my long-standing research program in intrusion detection and response), I have a deep understanding of what it takes to successfully model the behavior of people, computer systems, and their interactions.

   d) As a researcher in computer security and complex adaptive systems, I have extensive knowledge of the dynamics of systems where multiple parties cooperate, compete, and fight against each other over time. The code of Google's ad infrastructure is, in part, a record of how Google's relationship with advertisers, publishers, and other

actors has evolved over decades, and my research background allows me to recognize patterns in this dynamic.

12. My curriculum vitae is attached as Appendix D: Curriculum Vitae of Dr. Anil Somayaji to my report.

II.   SUMMARY OF OPINIONS

13. In this rebuttal report, I respond to Dr. Milgrom's claims that publishers and advertisers are able to optimize their behavior in response to the changes that Google introduces to its ad auction programs.[2]

14. My review of Google's source code and documents indicates that Google maintains an information advantage over all other parties participating in the Google ad ecosystem, whether they be advertisers, publishers, or third-party ad exchanges. This information imbalance between Google and non-Google participants impacts which ads are displayed, where they are shown, and the price that is paid for them.

15. This information imbalance can be seen in the information that is shared with advertisers and exchanges as part of each request for an ad—more publisher and user data is communicated to auctions involving Google's first-party tools than to auctions involving third-party tools and direct deals, including ███████████████████████████████████████

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16. As part of the process for conducting an auction for an ad slot, Google ████████████

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[2] Milgrom Report, ¶ 25.

████████████████████████████████████ To better understand Google's information advantage, I examined how the ad exchange and data flow mechanisms interact inside Google's ad infrastructure.

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18. My report proceeds as follows. First, in Section III, I discuss Dr. Milgrom's expert report, explaining how some of his arguments imply that Google does not have a significant information advantage over other participants. I then examine key portions of the source code of this infrastructure that illustrate 1) the information advantage that Google buying tools have over third-party buyers ████████████████████ in Section IV, and 2) in Section V, how Google's ██ ████████████████████████████████████. As such machine learning models are products of vast amounts of proprietary data, they add another layer to Google's information advantage.

III.   DR. MILGROM'S CLAIM ABOUT PUBLISHERS' AND ADVERTISERS' ABILITY TO OPTIMIZE THEIR BEHAVIOR FAILS TO CONSIDER GOOGLE'S INFORMATION ADVANTAGE

19. In his report, Dr. Milgrom discusses the purported benefits to publishers and advertisers of the contested Google auction programs,[3] and states that these programs are best understood in a historical context.[4] He also states that Google balances the interests of publishers and advertisers and that competitors have similar auction mechanisms or products.[5] He then focuses on the importance of incentives in the advertising market. Dr. Milgrom argues that advertisers and

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[3] *Ibid.*, ¶ 15.
[4] *Ibid.*, ¶ 18-20.
[5] *Ibid.*, ¶ 21-24.

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publishers have both the incentive and ability to optimize their behavior to achieve the outcomes they value.[6] Central to this argument is the observation that advertisers and publishers regularly conduct experiments in ad markets, and that Google offers features to facilitate those experiments.[7]

20. I note that Dr. Milgrom does not provide any support to suggest that experiments by advertisers and publishers are capable of revealing internal changes Google may make to its auction mechanisms or products. The ability of experiments to uncover underlying patterns of behavior depends on the complexity of the system being analyzed. The more complex the system is, the harder it is for experiments to give reliable insights. For instance, a lot can be understood about gravity just by observing the path of a thrown ball. Understanding the ability of an individual to jump, however, requires an understanding of biomechanics. And to understand <u>why</u> someone might choose to jump requires a deep understanding of the much more complicated human psychology, with such insights only being valid in the most general sense. It is my opinion that the degree to which experiments could give reliable insights into Google's internal operations would depend on the complexity of Google's systems. As I will explain, Google's ad infrastructure is extremely complex, and the insights that advertisers and publishers can glean are therefore limited.

21. I understand Dr. Milgrom to be opining that advertisers and publishers can "know" what Google does internally well enough to optimize their outcomes, or at least well enough to avoid unfavorable outcomes. I explore this assertion by examining the question of **information imbalance**, which in this report I define to mean that different parties possess different knowledge or amounts of knowledge in the context of any given ad auction. For example, there might be differences in the parties' knowledge of how a seller's impression is put up for auction or how buyers choose bids to submit to the auction. Thus, the information imbalance could affect how the winning bid and advertisement are determined in the auction.

22. Within the context of information imbalance, I refer to parties with relatively more knowledge or more detailed knowledge as having an **information advantage**, and I refer to parties with relatively less knowledge or less detailed knowledge as having an **information disadvantage**.

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[6] *Ibid.*, ¶ 25-31.
[7] *Ibid.*, ¶ 32-34.

23. The complexity of Google's ad infrastructure and the nature of the systems it contains thus directly pertain to Google's information advantage in online advertising facilitated through its platforms. To be specific, I can more easily understand the core information being used in Google's ad auctions by examining the code running those auctions. If the information available to different bidders is the same, it would be my opinion that there is no information imbalance within Google's advertisement system. However, if it can be shown that different parties have access to different information, and if that information can impact how auctions are conducted, it would instead be my opinion that there is an information imbalance that favors certain parties over others. Such is the case here. In the rest of this report, I discuss the information imbalances at the level of ad requests and auction bidding.

IV.   GOOGLE'S AD BUYING TOOLS HAVE ACCESS TO MORE GRANULAR TARGETING INFORMATION THAN DO THIRD-PARTY BUYERS

24. Dr. Milgrom argues that advertisers and publishers are incentivized and able to optimize their behavior in response to Google's changes to its auction programs through experimentation.[8] He ignores the fact that vastly different amounts of information are shared with Google's ad buying tools compared to third-party buyers. In this section, I examine the difference in request-level information that is passed to third-party buyers versus Google's first-party buying tools to determine the level of information imbalance between the external and internal auctions within Google's ad infrastructure. To this end, I reviewed Google's source code snapshots produced by Google in this matter to understand the information flows within Google's infrastructure.[9] Further detail is available in Appendix C: Source code appendix.

25. My review of Google's source code was an iterative process comprised in part of:

   a. Identifying the relevant code to be reviewed. To do this, I consulted Google's technical documents produced in this matter, which frequently included references to filenames, classes, and/or methods within the source code. These references provided a valuable

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[8] *Ibid.*, ¶ 25-34.
[9] While I primarily refer to the 2015 source code snapshot, I also examined other versions of the source code. ███████

foundation for my review. I also identified relevant code files by conducting keyword searches within the codebase.

b. Next, I analyzed the key functions of the code █████████████████████ ███.

c. During this process, I documented all my observations and findings, particularly noting request-level details of the requests made to and from first party and third-party buyers including the data types and fields used to represent them.

d. Throughout the process, I validated all my findings by cross-checking against Google documentation and reexamining the relevant code and function traces. ██████████ ██ ██ ████████████████████████████(Appendix C: Source code appendix).

26. The ad serving process begins when a user lands on a publisher's website. ██████████ ██ ██ ██ ██ ██ ██ ██ ████████████████████████.[10]

27. After █████████████████████████████████████

a) ██ █████████████████████[11]. █████████████████████████████ ██ ██

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[10] Hochstetler Report, ¶ 81, ¶117.
[11] *Ibid.*, ¶ 87.

b) ██████████████████████████ ██[12]██ ███████
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████████████████████████.[13]

28. I illustrate the above ad request process in Figure 1 below.

Figure 1: ███████████████████████
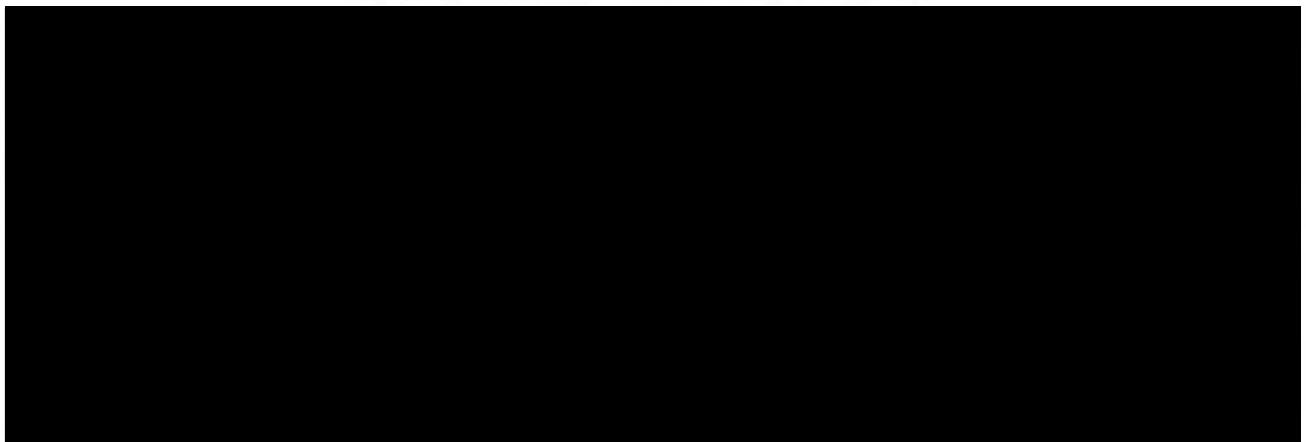
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[13] For simplicity, I use the term "third-party buyers" synonymously with "RTB buyers" to refer to third-party buying tools and exchanges that distribute ads through Google's ad infrastructure, █████████████████████████ ████████.

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A.   Information Given to Real Time Bidders

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██[16,17,18].

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Table 1 - ████████████ ████

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[14] Google, "Targeting Types", Google Ad Manager Help, https://support.google.com/admanager/answer/2884033 (accessed September 8, 2024).

[15] BidRequest is Google's code object that is sent to RTB buyers to request a bid for an incoming ad request. Google Developers, "Process the Request", Authorized Buyers, https://developers.google.com/authorized-buyers/rtb/request-guide (accessed September 8, 2024).

[16] While I specifically refer to the 2015 source code snapshot herein, I also examined other versions of the source code. As mentioned in Footnote 9, above, ████████████████████████████ ███ ███ ████████████████████████████████████

[17] ██

[18] Google, "Real-Time Bidding Protocol Buffer v.69", Real-Time Bidding Protocol, https://web.archive.org/web/20150923115610/https://developers.google.com/ad-exchange/rtb/downloads/realtime-bidding-proto (accessed September 8, 2024).

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33. ████ ████████ ███
████████████ ███[22]
████████████████ █████████████████████████[23] ██████ ██████ ██████
████████████.[24] █████████████████ █ ██████████████████████████

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[21] ██
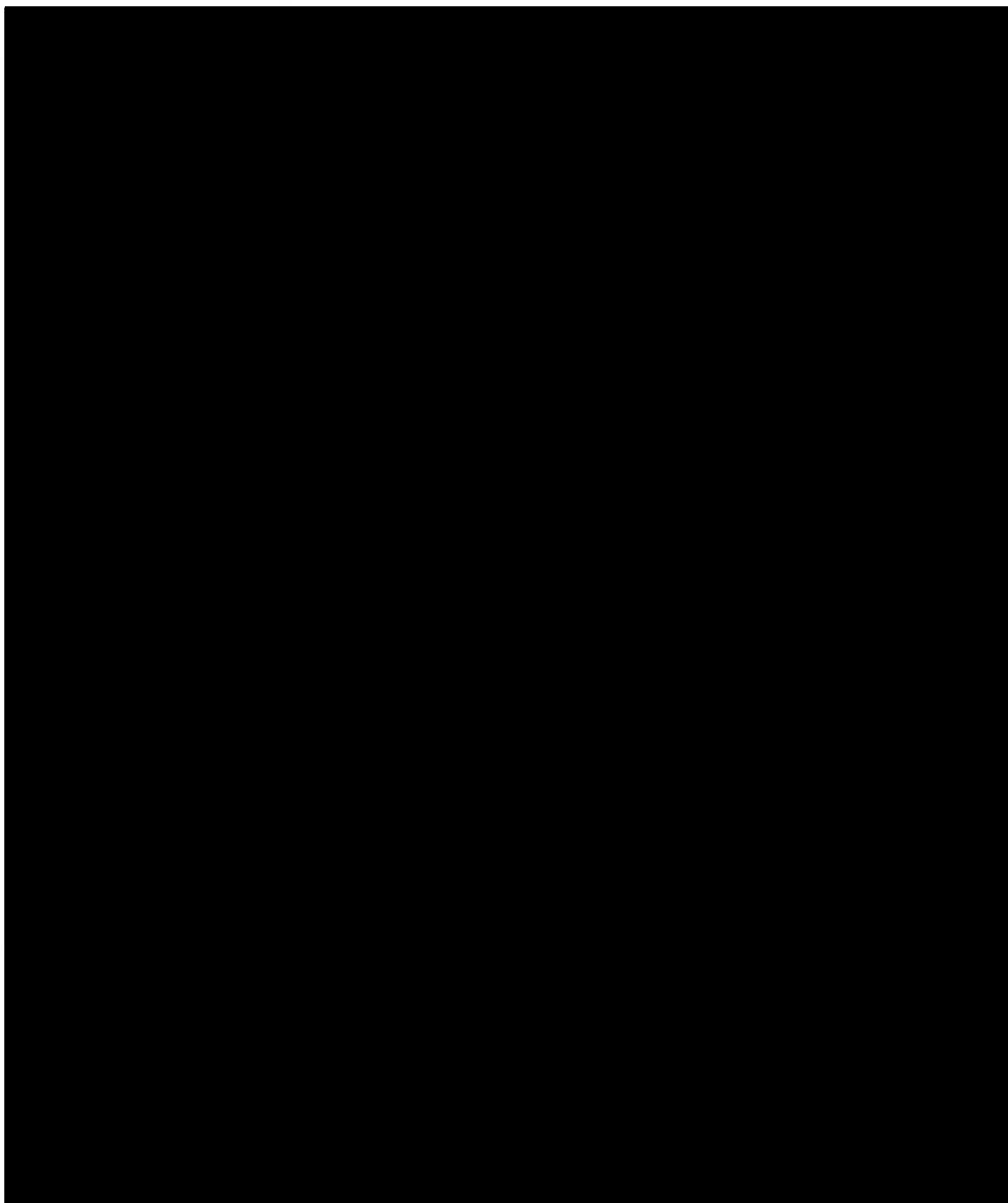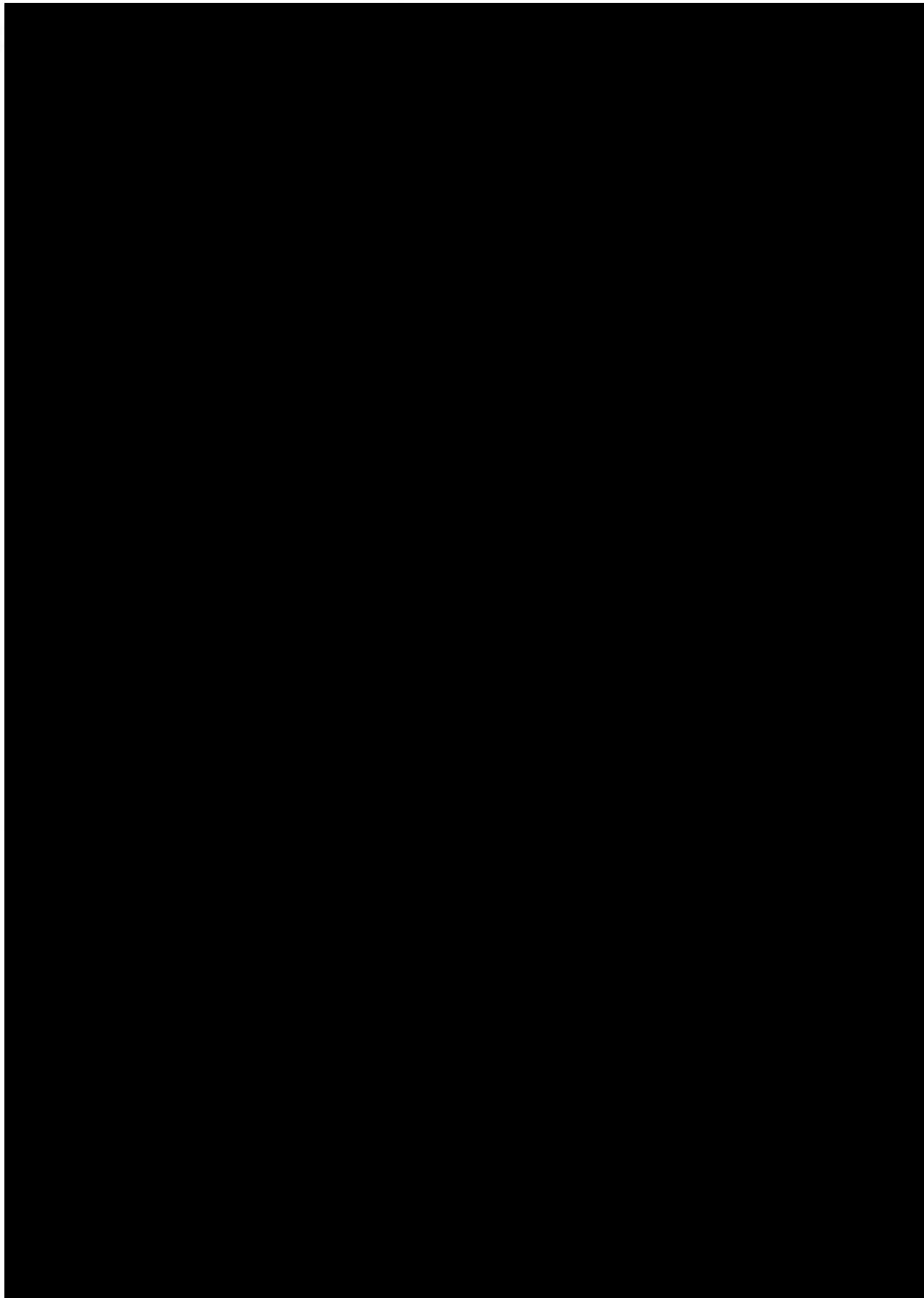
[22] Protocol buffer (protobuf) is an open-source, language- and platform-neutral data format developed by Google for serializing structured data. Protobuf, "Protocol Buffers", Protocol Buffers Documentation, https://protobuf.dev/ (accessed September 8, 2024).

[23] ██

[24] █████████████████████████████████

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██ [25]

B.   Selected differences in the information shared with Google's ad buying tools and RTB buyers

a)   ██████████████████████████

34.   ███

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█████████████████████████████ [26] ███████████████

████████████████████████████████ ""[27]

35.   ██

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███████████████████████████████████ [28]

36.   ██

████ ████ ██████ █ ██████ [29] ██████ ██ ██ ██ ██

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████████████████████████ [30] █████████████████

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[25] I have also observed that the latest publicly available `BidRequest` protobuf (Google, "Authorized Buyers Real-time Bidding Protocol Buffer", Authorized Buyers, https://developers.google.com/authorized-buyers/rtb/downloads/realtime-bidding-proto (accessed September 8, 2024)) contains more information than its 2015 counterpart. ██

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[26] ██

[27] ██

[28] Google, "Authorized Buyers Real-time Bidding Protocol Buffer", Authorized Buyers, https://developers.google.com/authorized-buyers/rtb/downloads/realtime-bidding-proto (accessed September 8, 2024).

[29] ██

[30] ██

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37. ██

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Table 2 – ████████████████ ████████████ ███████████ ██████ [31]

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[31] ██

[32] ██

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b)   ██████████████████████████

38. ████████ ██
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Table 3 - ██████████████████████████ ████████████ ████████ ████████

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[33] ██
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c)   ███████████████████████████

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Table 4 - ████████████████████ █████████ █████
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40. ██
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███████████████████[35] █████████████████████
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███████████████[36] ██████████████████████████
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███████[37]

41. ██
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[34] ████████████████████████████████████
[35] Hochstetler Report, ¶ 78.
[36] Hochstetler Report, ¶ 78.
[37] ██

HIGHLY CONFIDENTIAL – SOURCE CODE   19

a) ███████████████████████████████████
███████████████████████████████████
███████████████████████████████████
████████████████ [38]

b) ███████████████████████████████████
███████████████████████████████████████
███████████████████████████████
███████████████████████████████████ "[39]

c) ███████████████████████████████████
███████████████████████████████
███████████ [40]

42. ███████████████████████████████████████
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V.   GOOGLE ████████████████████████████
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43. Dr. Milgrom claims that advertisers and publishers are able to experiment and adjust their auction behavior in order to optimize returns,[41] without addressing the impact of the information imbalance between ████████████████████████████████ ██████, which I analyzed in the previous section. In my review of the produced Google ad infrastructure code, I have further observed ████████████████████████ ███████████████████████████████████████ ██████████████████████████████)[42] ██████████████

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[38] ███
[39] ███
[40] ███
[41] Milgrom Report, ¶ 32-34.
[42] Google Ads Help, Google, "Clickthrough rate (CTR): Definition", https://support.google.com/google-ads/answer/2615875?hl=en (accessed September 8, 2024).

███. [43]

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Figure 2: ██[44]

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44. ██

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██. [45]

45. ██

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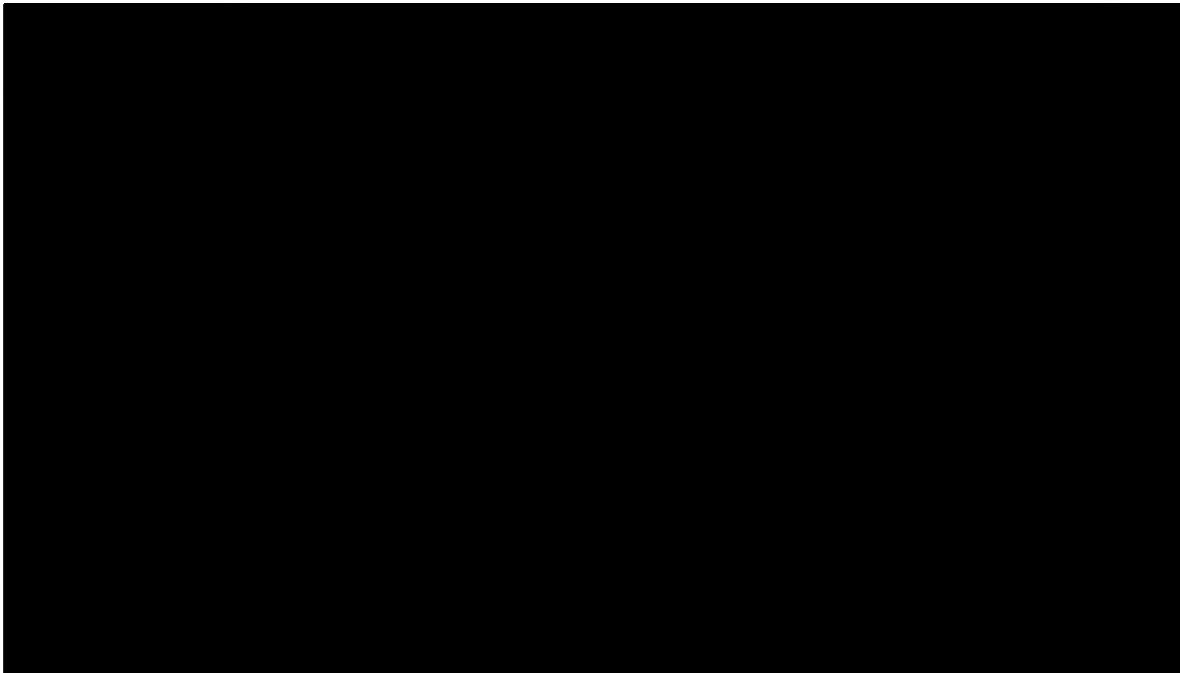
[43] As mentioned earlier, I also examined other versions of the source code, ████████████████████ ████████████████████████ ████████████████████████████ ████████████████████ .

[44] ██ █

[45] ██

███████████████████████ [46] ████████████████████████

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███ [48]

46. ██

███ [49] ██████

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[51] ██
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VI.   APPENDIX A: MATERIALS RELIED UPON

A.   Expert Reports

2024.06.07 Expert Report of Jacob Hochstetler

2024.07.30 Expert Report of Paul R. Milgrom

B.   Documents from Production

GOOG-AT-MDL-001283820

GOOG-AT-MDL-009414680

GOOG-AT-MDL-015554886

GOOG-AT-MDL-018512842

GOOG-AT-MDL-B-003952932

GOOG-AT-MDL-B-005080323

GOOG-DOJ-AT-02492756

GOOG-AT-MDL-012693796

C.   Source Code Files

D.   Public Sources

Google Ad Manager Help, Google, "Targeting Types", https://support.google.com/admanager/answer/2884033?sjid=5613954590018599404-NC. Accessed on September 8, 2024.

Google Ads Help, Google, "Clickthrough rate (CTR): Definition", https://support.google.com/google-ads/answer/2615875?hl=en. Accessed September 8, 2024.

Google Developers, Authorized Buyers, "Process the Request", https://developers.google.com/authorized-buyers/rtb/request-guide. Accessed September 8, 2024.

Google, "Real-Time Bidding Protocol Buffer v.69", Real-Time Bidding Protocol, https://web.archive.org/web/20150923115610/https://developers.google.com/ad-exchange/rtb/downloads/realtime-bidding-proto. Accessed September 8, 2024.

Google Developers, Google, "Authorized Buyers Real-time Bidding Protocol Buffer", https://developers.google.com/authorized-buyers/rtb/downloads/realtime-bidding-proto. Accessed September 8, 2024.

Google, Google Ads Help, "Cost-per-thousand impressions (CPM): Definition", https://support.google.com/google-ads/answer/6310. Accessed September 8, 2024.

Mozilla, "MIME types (IANA media types)", https://developer.mozilla.org/en-US/docs/Web/HTTP/Basics_of_HTTP/MIME_types. Accessed September 8, 2024.

IAB Tech Lab, "Content Taxonomy", https://iabtechlab.com/standards/content-taxonomy/. Accessed September 8, 2024.

Protobuf, "Protocol Buffers", Protocol Buffers Documentation, https://protobuf.dev/. Accessed September 8, 2024.

VII.   APPENDIX B: MATERIALS CONSIDERED

A.   Discovery Responses

All available discovery responses produced within the matter of *The State of Texas, et al. v. Google*, Case Number: 4:20-cv-00957-SDJ, including:

1. The Parties' amended initial disclosures;
2. The Parties' discovery responses and objections to Interrogatories, Requests for Admission, and Requests for Production; and
3. Google's written responses to Plaintiffs' Rule 30(b)(6) Notice.

B.   Case Filings

The live pleadings (complaint and answer) within the matter of The State of Texas, et al. v. Google, Case Number: 4:20-cv-00957-SDJ, including the Fourth Amended Complaint.

C.   Declarations, Depositions and ROG Responses

Deposition Transcripts & Exhibits

All available deposition transcripts and exhibits within the matter of *The State of Texas, et al. v. Google*, Case Number: 4:20-cv-00957-SDJ, including:

1. Deposition and Exhibits of ███████   April 1, 2024
2. Deposition and Exhibits of ███████, April 3, 2024
3. Deposition and Exhibits of ███████, April 12, 2024
4. Deposition and Exhibits of ███████, April 17, 2024
5. Deposition and Exhibits of ███████, April 19, 2024
6. Deposition and Exhibits of ███████, April 23, 2024
7. Deposition and Exhibits of ███████, April 26, 2024
8. Deposition and Exhibits of ███████, April 26, 2024
9. Deposition and Exhibits of ███████, April 29, 2024
10. Deposition and Exhibits of ███████, April 30, 2024
11. Deposition and Exhibits of ███████, May 1, 2024
12. Deposition and Exhibits of ███████ May 1, 2024
13. Deposition and Exhibits of ███████, May 2, 2024
14. Deposition and Exhibits of ███████, April 5, 2024
15. Deposition and Exhibits of ███████, May 2, 2024
16. Deposition and Exhibits of ███████, May 10, 2024
17. Deposition and Exhibits of ███████, May 15, 2024
18. Deposition and Exhibits of ███████ May 17, 2024
19. Deposition and Exhibits of ███████ Vol 1, April 26, 2024
20. Deposition and Exhibits of ███████ Vol 2, May 21, 2024
21. Deposition and Exhibits of ███████, May 21, 2024
22. Deposition and Exhibits of ███████, May 22, 2024

23. Deposition and Exhibits of ██████████, May 23, 2024
24. Deposition and Exhibits of ████████, May 24, 2024
25. Deposition and Exhibits of █████████ Vol 1, April 19, 2024
26. Deposition and Exhibits of █████████ Vol 2, May 2, 2024
27. Deposition and Exhibits of █████████ Vol 3, May 3, 2024
28. Deposition and Exhibits of █████████ Vol 4, May 24, 2024
29. Deposition and Exhibits of ██████████, May 2, 2024
30. Deposition and Exhibits of ████████, May 23, 2024
31. Deposition and Exhibits of ███████, May 3, 2024
32. Deposition and Exhibits of ██████, May 3, 2024
33. Deposition and Exhibits of ████████████, May 23, 2024
34. Deposition and Exhibits of ██████████████, April 30, 2024
35. Deposition and Exhibits of █████████████████, May 2, 2024
36. Deposition and Exhibits of ███████████████, May 1, 2024
37. Deposition and Exhibits of ████████████ May 1, 2024
38. Deposition and Exhibits of ████████████, April 16, 2024
39. Deposition and Exhibits of ███████████████, April 23, 2024
40. Deposition and Exhibits of ████████, April 25, 2024
41. Deposition and Exhibits of ████████████, April 12, 2024
42. Deposition and Exhibits of ████████████ April 19, 2024
43. Deposition and Exhibits of ██████, April 30, 2024
44. Deposition and Exhibits of ██████, May 2, 2024
45. Deposition and Exhibits of ██████████████████, May 3, 2024
46. Deposition and Exhibits of ██████████████, May 1, 2024
47. Deposition and Exhibits of ███████████, April 22, 2024
48. Deposition and Exhibits of ████████████, May 1, 2024
49. Deposition and Exhibits of █████████████ May 3, 2024
50. Deposition and Exhibits of ██████████████, April 29, 2024
51. Deposition and Exhibits of ████████, April 25, 2024
52. Deposition and Exhibits of South Carolina (██████████), April 23, 2024
53. Deposition and Exhibits of Indiana (████████), April 26, 2024
54. Deposition and Exhibits of Indiana (████████), April 26, 2024
55. Deposition and Exhibits of Nevada (██████), April 29, 2024
56. Deposition and Exhibits of Arkansas (███████), May 1, 2024
57. Deposition and Exhibits of Alaska (███████), May 3, 2024
58. Deposition and Exhibits of Florida (████████), April 22, 2024
59. Deposition and Exhibits of Idaho (███████), May 3, 2024
60. Deposition and Exhibits of Idaho (████████), May 3, 2024
61. Deposition and Exhibits of Kentucky (████████), April 25, 2024
62. Deposition and Exhibits of Louisiana (████████), May 3, 2024
63. Deposition and Exhibits of Mississippi (████████), April 25, 2024
64. Deposition and Exhibits of Mississippi (████████), April 25, 2024
65. Deposition and Exhibits of Missouri (█████████), May 10, 2024

66. Deposition and Exhibits of Montana (█████████), May 1, 2024
67. Deposition and Exhibits of North Dakota (████████), May 2, 2024
68. Deposition and Exhibits of Puerto Rico (███████████████), May 1, 2024
69. Deposition and Exhibits of South Dakota (█████████████), April 29, 2024
70. Deposition and Exhibits of Texas (████████), May 24, 2024
71. Deposition and Exhibits of Texas (████████), April 17, 2024
72. Deposition and Exhibits of Utah (██████████), April 30, 2024
73. Deposition and Exhibits of Utah (██████████), April 30, 2024
74. Deposition and Exhibits of ████████████████████████ ███████), May 1, 2024
75. Deposition and Exhibits of ████████████████████████ (█████████), May 1, 2024
76. Deposition and Exhibits of ████████████████████████ (█████████), May 3, 2024
77. Deposition and Exhibits of ██████████████ (████████), April 3, 2024
78. Deposition and Exhibits of ████████████████ █████████), May 2, 2024
79. Deposition and Exhibits of ██████████████ (████████ May 1, 2024
80. Deposition and Exhibits of ████████ ████████), May 3, 2024
81. Deposition and Exhibits of ████████ ████████), May 3, 2024
82. Deposition and Exhibits of ██████████████ (██████████████████), April 29, 2024
83. Deposition and Exhibits of ██████████████ (█████████), April 29, 2024
84. Deposition and Exhibits of ████████████████████), April 19, 2024

All available deposition transcripts and exhibits within the matter of *USA v. Google*, Case Number: 1:23-cv-00108-LMB-JFA, including:

1. Deposition and Exhibits of █████, August, 16 2023
2. Deposition and Exhibits of █████, September 1, 2023
3. Deposition and Exhibits of █████, August 29, 2023
4. Deposition and Exhibits of █████, September 6, 2023
5. Deposition and Exhibits of █████, September 8, 2023
6. Deposition and Exhibits of █████, September 29, 2024
7. Deposition and Exhibits of █████, September 5, 2023
8. Deposition and Exhibits of █████, September 26, 2023
9. Deposition and Exhibits of █████, September 8, 2023
10. Deposition and Exhibits of ████████, September 26, 2023
11. Deposition and Exhibits of █████, August 9, 2023
12. Deposition and Exhibits of ██████, August 31, 2023
13. Deposition and Exhibits of ███████, September 22, 2023
14. Deposition and Exhibits of █████, September 28, 2023
15. Deposition and Exhibits of ███████, September 8, 2023

16.   Deposition and Exhibits of ███████████, September 21, 2023
17.   Deposition and Exhibits of ███████████, August 25, 2023
18.   Deposition and Exhibits of ████████, August 25, 2023
19.   Deposition and Exhibits of ███████, September 22, 2023
20.   Deposition and Exhibits of █████████, September 29, 2023
21.   Deposition and Exhibits of ████████, August 29, 2023
22.   Deposition and Exhibits of ██████, October 26, 2023
23.   Deposition and Exhibits of ████████ July 28, 2023
24.   Deposition and Exhibits of ████, August 23, 2023
25.   Deposition and Exhibits of █████, September 28, 2023
26.   Deposition and Exhibits of ██████████ (November, 11, 2023)
27.   Deposition and Exhibits of █████████ (August 15, 2023)
28.   Deposition and Exhibits of ██████████ (November 14, 2023)
29.   Deposition and Exhibits of ████████ (November 15, 2023)
30.   Deposition and Exhibits of █████████ (November 14, 2023)
31.   Deposition and Exhibits of ████████ (30B6 errata only) (November 14, 2023)
32.   Deposition and Exhibits of ████████ (November 3, 2023)
33.   Deposition and Exhibits of ███████ (August 16, 2023)
34.   Deposition and Exhibits of ███████ (November 7, 2023)
35.   Deposition and Exhibits of █████████ November 9, 2023)
36.   Deposition and Exhibits of █████████ (October 30, 2023)
37.   Deposition and Exhibits of ██████████ (August 11, 2023)
38.   Deposition and Exhibits of ██████████ (November 2, 2023)
39.   Deposition and Exhibits of ███████████ (November 16, 2023)
40.   Deposition and Exhibits of ███████████ (August 29, 2023)
41.   Deposition and Exhibits of ██████ (November 14-15, 2023)
42.   Deposition and Exhibits of ██████ (April 1, 2024)
43.   Deposition and Exhibits of ████████████ (November 3, 2024)
44.   Deposition and Exhibits of █████████ (November 3, 2024)
45.   Deposition and Exhibits of █████████ (30(b)6) (November 14, 2023)
46.   Deposition and Exhibits of ████████ (August 16, 2023)
47.   Deposition and Exhibits of ████████ (November 7, 2023)
48.   Deposition and Exhibits of █████████ (November 9, 2023)
49.   Deposition and Exhibits of ██████ (April 3, 2024)
50.   Deposition and Exhibits of █████████ (October 10, 2023 and November 8, 2023)
51.   Deposition and Exhibits of ██████ (April 17, 2024)
52.   Deposition and Exhibits of █████████ (April 29, 2024)
53.   Deposition and Exhibits of ████████ (Noveber 11, 2023)
54.   Deposition and Exhibits of █████████ (October 10, 2023)

All available deposition transcripts and exhibits within the matter of *In re: Google Digital Advertising Antitrust Litigation*, Case Number: 1:21-md-03010-PKC, including the depositions and exhibits of:

#		Date
1.	███████	6/19/2024
2.	███████	6/20/2024
3.	███████	6/21/2024
4.	███████	5/21/2024
5.	███████	6/25/2024
6.	███████	6/25/2024
7.	███████	6/27/2024
8.	███ (Google)	7/23/2024
9.	███ (Google)	7/23/2024
10.	███████	6/18/2024
11.	███████	5/7/2024
12.	███████ (Advertiser)	7/9/2024
13.	███████	7/10/2024
14.	███████	4/25/2024
15.	███████	7/10/2024
16.	███████	6/24/2024
17.	███████	7/12/2024
18.	███████	6/12/2024
19.	███████ e	6/13/2024
20.	███████	5/2/2024
21.	███████	6/28/2024
22.	███████	6/6/2024
23.	███ (Google)	6/28/2024
24.	███████	7/3/2024
25.	███████	6/4/2024
26.	███████	7/28/2024
27.	███████	7/10/2024
28.	███████	6/25/2024
29.	███████	6/26/2024
30.	███████	6/10/2024
31.	███████	6/27/2024
32.	███████	6/13/2024
33.	███████	6/7/2024
34.	███████	6/25/2024
35.	███████	6/28/2024
36.	███████	5/24/2024
37.	███████	6/24/2024
38.	███████	6/27/2024
39.	███████	6/11/2024
40.	███████	6/12/2024

Other available deposition transcripts and exhibits, including the depositions and exhibits of:

#		Date
1.	███████	10/2/2020

2.	███████████	10/16/2020
3.	███████████	7/28/2020
4.	███████████	7/21/2020
5.	███████████	10/26/2020
6.	███████████	11/6/2020
7.	███████████	7/31/2020
8.	███████████	9/25/2020
9.	███████████	10/20/2020
10.	███████████	7/17/2020
11.	███████████	11/9/2020
12.	███████████	11/19/2020
13.	███████████	7/24/2020
14.	███████████	7/14/2020
15.	███████████	11/10/2020
16.	███████████	11/2/2020
17.	███████████	9/28/2020
18.	███████████	2/3/2022
19.	███████████	8/11/2021
20.	███████████	2/28/2022
21.	███████████	10/19/2021
22.	███████████	12/9/2021
23.	███████████	9/17/2021
24.	███████████	11/20/2020
25.	███████████	3/30/2021
26.	███████████	10/28/2021
27.	███████████	8/10/2021
28.	███████████	3/31/2021
29.	███████████	4/2/2021
30.	███████████	4/22/2021
31.	███████████	10/28/2021
32.	███████████	7/22/2021
33.	███████████	10/6/2021
34.	███████████	7/20/2021
35.	███████████	8/12/2021
36.	███████████	9/28/2021
37.	███████████	5/17/2021
38.	███████████	9/7/2021

D.   Expert Reports

Expert Reports & Declarations

All available expert reports, including appendices, backup materials, and cited materials, within the matter of *The State of Texas, et al. v. Google*, Case Number: 4:20-cv-00957-SDJ, including:

1. 2024.06.07 Expert Report of Jeffrey S. Andrien
2. 2024.06.07 Expert Report of Joshua Gans, as well as 2024.07.24 Errata and Supplemental Appendix D
3. 2024.06.07 Expert Report of Jacob Hochstetler
4. 2024.06.07 Expert Report of John Chandler
5. 2024.06.07 Expert Report of Matthew Weinberg
6. 2024.06.07 Expert Report of Parag Pathak
7. 2024.07.30 Expert Report of Anindya Ghose
8. 2024.07.30 Expert Report of Donna L. Hoffman
9. 2024.07.30 Expert Report of Douglas Skinner
10. 2024.07.30 Expert Report of Itamar Simonson
11. 2024.07.30 Expert Report of Martin C. Rinard
12. 2024.07.30 Expert Report of Paul R. Milgrom
13. 2024.07.30 Expert Report of Steven N. Wiggins
14. 2024.08.06 Expert Report of Michael R. Baye
15. 2024.08.06 Expert Report of Jason Nieh

All available expert reports (with redactions) within the matter of *USA v. Google*, Case Number: 1:23-cv-00108-LMB-JFA, including:

1. Declarations of Google Employees
2. 2023.12.22 Expert Report of Gabriel Weintraub, GOOG-AT-MDL-C-000018734
3. 2023.12.22 Expert Report of R. Ravi, GOOG-AT-MDL-C-000019017
4. 2023.12.22 Expert Report of Robin S. Lee, GOOG-AT-MDL-C-000019273
5. 2023.12.22 Expert Report of Rosa Abrantes-Metz, GOOG-AT-MDL-C-000019786
6. 2023.12.22 Expert Report of Thomas S. Respess, GOOG-AT-MDL-C-000020106
7. 2023.12.22 Expert Report of Timothy Simcoe, GOOG-AT-MDL-C-000020274
8. 2024.01.13 Errata to Abrantes-Metz Expert Report, GOOG-AT-MDL-C-000020435
9. 2024.01.13 Errata to Ravi Expert Report, GOOG-AT-MDL-C-000020437
10. 2024.01.13 Errata to Respess Expert Report, GOOG-AT-MDL-C-000020440
11. 2024.01.13 Errata to Simcoe Expert Report, GOOG-AT-MDL-C-000020467
12. 2024.01.13 Errata to Weintraub Expert Report, GOOG-AT-MDL-C-000020471
13. 2024.01.23 Chevalier Expert Report, GOOG-AT-MDL-C-000020474
14. 2024.01.23 Ferrante Expert Report, GOOG-AT-MDL-C-000020714
15. 2024.01.23 Ghose Expert Report, GOOG-AT-MDL-C-000020767
16. 2024.01.23 Israel Expert Report, GOOG-AT-MDL-C-000021036
17. 2024.01.23 Milgrom Expert Report, GOOG-AT-MDL-C-000021794
18. 2024.01.23 Rinard Expert Report, GOOG-AT-MDL-C-000022191
19. 2024.01.23 Shirky Expert Report, GOOG-AT-MDL-C-000022229
20. 2024.01.23 Simonson Expert Report, GOOG-AT-MDL-C-000022290
21. 2024.01.23 Skinner Expert Report, GOOG-AT-MDL-C-000022948

22. 2024.02.13 Expert Rebuttal Report of Adoria Lim, GOOG-AT-MDL-C-000023002

23. 2024.02.13 Expert Rebuttal Report of Gabriel Weintraub, GOOG-AT-MDL-C-000023226

24. 2024.02.13 Expert Rebuttal Report of Kenneth Wilbur, GOOG-AT-MDL-C-000023322

25. 2024.02.13 Expert Rebuttal Report of R. Ravi, GOOG-AT-MDL-C-000023435

26. 2024.02.13 Expert Rebuttal Report of Robin S. Lee, GOOG-AT-MDL-C-000023516

27. 2024.02.13 Expert Rebuttal Report of Rosa Abrantes-Metz, GOOG-AT-MDL-C-000023887
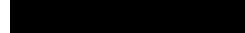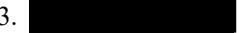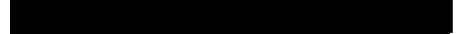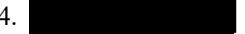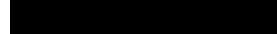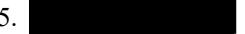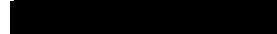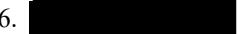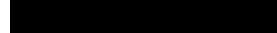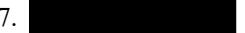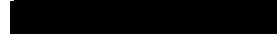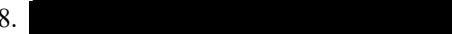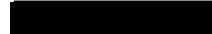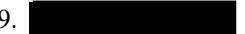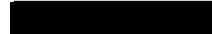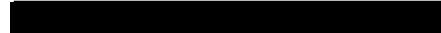
28. 2024.02.13 Expert Rebuttal Report of Timothy Simcoe, GOOG-AT-MDL-C-000024064

29. 2024.02.13 Expert Rebuttal Report of Wayne Hoyer, GOOG-AT-MDL-C-000024138

30. 2024.02.13 Expert Rebuttal Report of Wenke Lee, GOOG-AT-MDL-C-000024270

31. 2024.02.16 Errata to Ravi Rebuttal Report, GOOG-AT-MDL-C-000024387

32. 2024.02.20 Errata to Simcoe Rebuttal Report, GOOG-AT-MDL-C-000024389

33. 2024.02.23 Errata to Weintraub Rebuttal Report, GOOG-AT-MDL-C-000024390

34. 2024.02.23 Supplemental Errata to Weintraub Expert Report, GOOG-AT-MDL-C-000024391

35. 2024.02.24 Errata to Wilbur Rebuttal Report, GOOG-AT-MDL-C-000024392

36. 2024.02.26 Errata to Hoyer Rebuttal Report, GOOG-AT-MDL-C-000024397

37. 2024.02.28 Errata to Abrantes-Metz Rebuttal Report, GOOG-AT-MDL-C-000024399

38. 2024.03.04 Expert Supplemental Report of Robin S. Lee, GOOG-AT-MDL-C-000024403

39. 2024.03.08 Consolidated Errata to Lee Rebuttal Report, GOOG-AT-MDL-C-000024436

40. 2024.01.13 Expert Report of Weintraub Errata, GOOG-AT-MDL-C-000040965

41. 2024.01.13 Expert Report of Simcoe Errata, GOOG-AT-MDL-C-000040961

42. 2024.01.13 Expert Report of Respess Errata_with Figure Errata_Redacted, GOOG-AT-MDL-C-000040934

43. 2024.01.13 Expert Report of R Ravi Errata, GOOG-AT-MDL-C-000040931

44. 2024.01.13 Expert Report of Abrantes-Metz Errata, GOOG-AT-MDL-C-000040929

45. 2024.03.08 Consolidated Errata to Lee Rebuttal Report, GOOG-AT-MDL-C-000040926

46. 2024.03.04 Expert Supplemental Report of Robin S. Lee, PhD, GOOG-AT-MDL-C-000040893

47. 2024.02.28 Rebuttal Report Errata of Rosa Abrantes-Metz Signed, GOOG-AT-MDL-C-000040889

48. 2024.02.25 Expert Rebuttal Report of Hoyer Errata, GOOG-AT-MDL-C-000040887

49. 2024.02.24 Wilbur Rebuttal Errata, GOOG-AT-MDL-C-000040882

50. 2024.02.23 Weintraub Rebuttal Report Errata, GOOG-AT-MDL-C-000040881

51. 2024.02.23 Expert Report of Weintraub Supplemental Errata, GOOG-AT-MDL-C-000040880

52. 2024.02.20 Errata to Simcoe Rebuttal Report, GOOG-AT-MDL-C-000040879

53. 2024.02.16 Errata to Ravi Rebuttal Report (Highly Confidential), GOOG-AT-MDL-C-000040877

54. 2024.02.13 Rebuttal Report of Rosa Abrantes-Metz, GOOG-AT-MDL-C-000040700

55. 2024.02.13 Expert Report of Wenke Lee, GOOG-AT-MDL-C-000040583

56. 2024.02.13 Expert Rebuttal Report of Wayne Hoyer, GOOG-AT-MDL-C-000040451

57. 2024.02.13 Expert Rebuttal Report of Timothy Simcoe_Redacted, GOOG-AT-MDL-C-000040377
58. 2024.02.13 Expert Rebuttal Report of Robin S. Lee_Redacted, GOOG-AT-MDL-C-000040006
59. 2024.02.13 Expert Rebuttal Report of R Ravi, GOOG-AT-MDL-C-000039925
60. 2024.02.13 Expert Rebuttal Report of Kenneth Wilbur_Redacted, GOOG-AT-MDL-C-000039812
61. 2024.02.13 Expert Rebuttal Report of Gabriel Weintraub_Redacted, GOOG-AT-MDL-C-000039716
62. 2024.02.13 Expert Rebuttal Report of Adoria Lim_Redacted, GOOG-AT-MDL-C-000039492
63. 2024.01.23 Expert Report of William Clay Shirky, GOOG-AT-MDL-C-000039431
64. 2024.01.23 Expert Report of Paul R. Milgrom, GOOG-AT-MDL-C-000039034
65. 2024.01.23 Expert Report of Martin C. Rinard, GOOG-AT-MDL-C-000038996
66. 2024.01.23 Expert Report of Mark A. Israel_Redacted, GOOG-AT-MDL-C-000038238
67. 2024.01.23 Expert Report of Judith A. Chevalier_Redacted, GOOG-AT-MDL-C-000037998
68. 2024.01.23 Expert Report of Itamar Simonson, GOOG-AT-MDL-C-000037340
69. 2024.01.23 Expert Report of Douglas Skinner, GOOG-AT-MDL-C-000037286
70. 2024.01.23 Expert Report of Anthony J. Ferrante, GOOG-AT-MDL-C-000037233
71. 2024.01.23 Expert Report of Anindya Ghose_Redacted, GOOG-AT-MDL-C-000036954
72. 2023.12.22 Expert Report of Timothy Simcoe_Redacted, GOOG-AT-MDL-C-000036793
73. 2023.12.22 Expert Report of Thomas Respess_Redacted, GOOG-AT-MDL-C-000036625
74. 2023.12.22 Expert Report of Rosa Abrantes-Metz_Redacted, GOOG-AT-MDL-C-000036305
75. 2023.12.22 Expert Report of Robin S. Lee, PhD_Redacted, GOOG-AT-MDL-C-000035792
76. 2023.12.22 Expert Report of R Ravi_Redacted, GOOG-AT-MDL-C-000035536
77. 2023.12.22 Expert Report of Gabriel Weintraub_Redacted, GOOG-AT-MDL-C-000035253

E.   Documents from Production

<u>Bates Stamped Productions, including access to Plaintiffs' entire production database, as well as the following documents and Google and third-party productions made since June 7, 2024:</u>

1. ███████████
2. ██████████████████
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39. FTC_US-GOOGLE-000004531

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478. GOOG-DOJ-AT-02411973
479. GOOG-DOJ-AT-02478780
480. GOOG-DOJ-AT-02482767
481. GOOG-DOJ-AT-02492756
482. GOOG-DOJ-AT-02493711
483. GOOG-DOJ-AT-02634336
484. GOOG-DOJ-AT-02639830
485. GOOG-NE-01787563
486. GOOG-NE-02557667
487. GOOG-NE-02558055
488. GOOG-NE-03231727
489. GOOG-NE-03236272
490. GOOG-NE-03467508
491. GOOG-NE-03616222
492. GOOG-NE-03627597
493. GOOG-NE-03727816
494. GOOG-NE-03727939
495. GOOG-NE-03844060
496. GOOG-NE-03869994
497. GOOG-NE-03872605
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499. GOOG-NE-04689402
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501. GOOG-NE-05243813
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503. GOOG-NE-05279363
504. GOOG-NE-06113062

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505. GOOG-NE-06181135

506. GOOG-NE-06547825

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516. GOOG-NE-09138394

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518. GOOG-NE-09711564

519. GOOG-NE-10573952

520. GOOG-NE-10660658

521. GOOG-NE-10660882

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524. GOOG-NE-10976657

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526. GOOG-NE-10978402

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530. GOOG-NE-11877282

531. GOOG-NE-12727978

532. GOOG-NE-12738745

533. GOOG-NE-12742008

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544. GOOG-NE-13367768

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560. GOOG-NE-13589899

561. GOOG-NE-13624783

562. GOOG-TEX-00001418

563. GOOG-TEX-00039266

564. GOOG-TEX-00079344

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566. GOOG-TEX-00090151

567. GOOG-TEX-00090282

568. GOOG-TEX-00090969

569. GOOG-TEX-00092657

570. GOOG-TEX-00105202

571. GOOG-TEX-00105361

572. GOOG-TEX-00106255

573. GOOG-TEX-00109167

574. GOOG-TEX-00110068

575. GOOG-TEX-00110540

576. GOOG-TEX-00110544

577. GOOG-TEX-00111494

578. GOOG-TEX-00116069

579. GOOG-TEX-00116639

580. GOOG-TEX-00119737

581. GOOG-TEX-00119845

582. GOOG-TEX-00120626

583. GOOG-TEX-00120775

584. GOOG-TEX-00156142

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600. GOOG-TEX-00452866
601. GOOG-TEX-00513684
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608. GOOG-TEX-00777573

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611. GOOG-TEX-00806640
612. GOOG-TEX-00806682
613. GOOG-TEX-00814407
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626. GOOG-TEX-01036150
627. GOOG-TEX-01142635
628. GOOG-TEX-01244428
629. GOOG-TEX-01279945
630. ███████████████
631. ████████████

E.   Source Code Files

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VIII.   APPENDIX C: SOURCE CODE APPENDIX

A. ██████████████████

1. ██
████████████████████████████[52] █████████████████████████████[53]█████████
██
██
████████████████████████ █ ██
████████████████.

2. ██
██████████████████████[54]

3. ██
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[52] While I refer to the 2015 code snapshot, I also reviewed the additional snapshots produced by Google. ███████████████████████
████████████████████

[53] ███████████████ █ ██
████████████████████

[54] Google, "Authorized Buyers Real-time Bidding Protocol Buffer", Google Developers, https://developers.google.com/authorized-buyers/rtb/downloads/realtime-bidding-proto (accessed September 8, 2024).
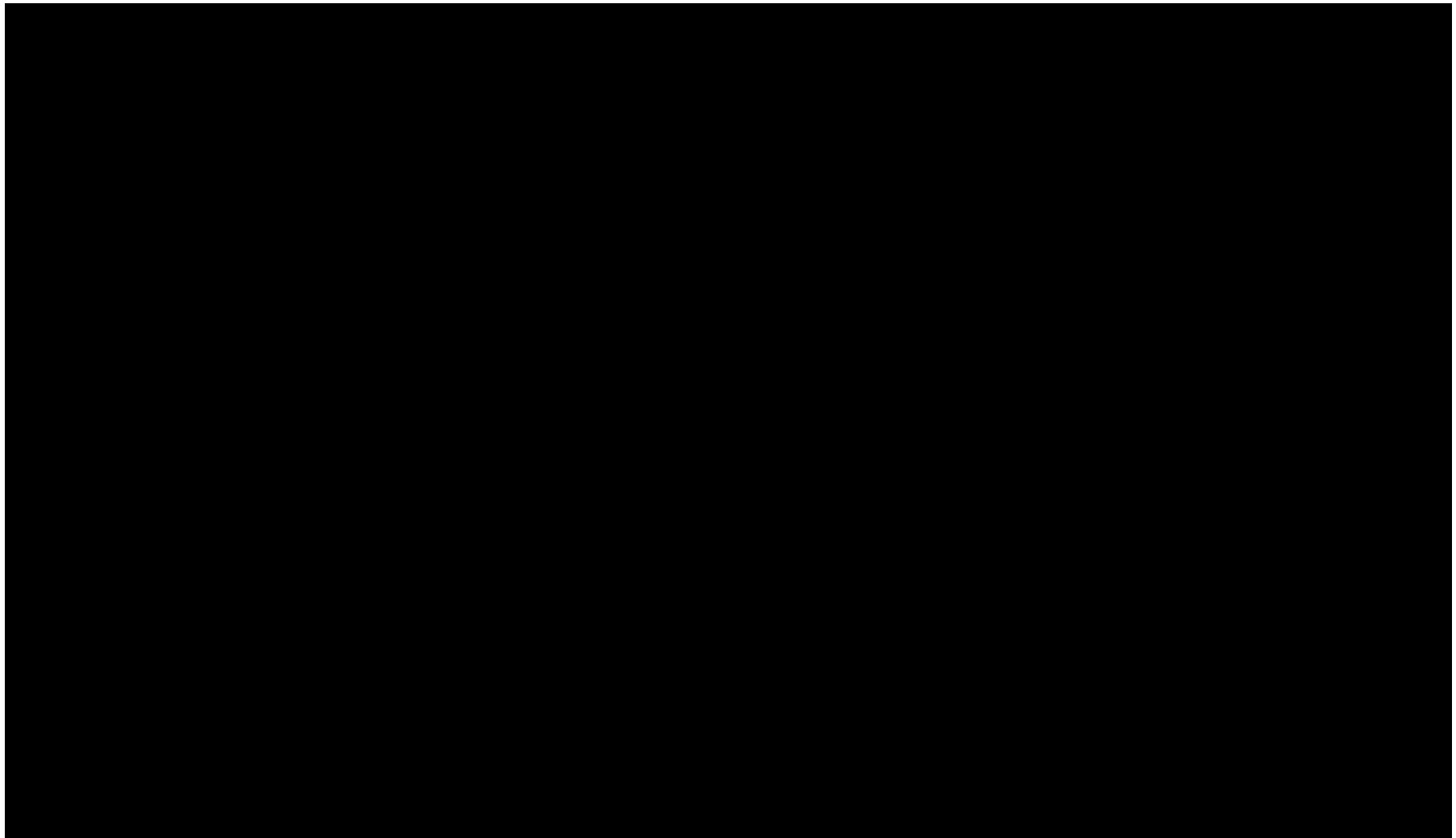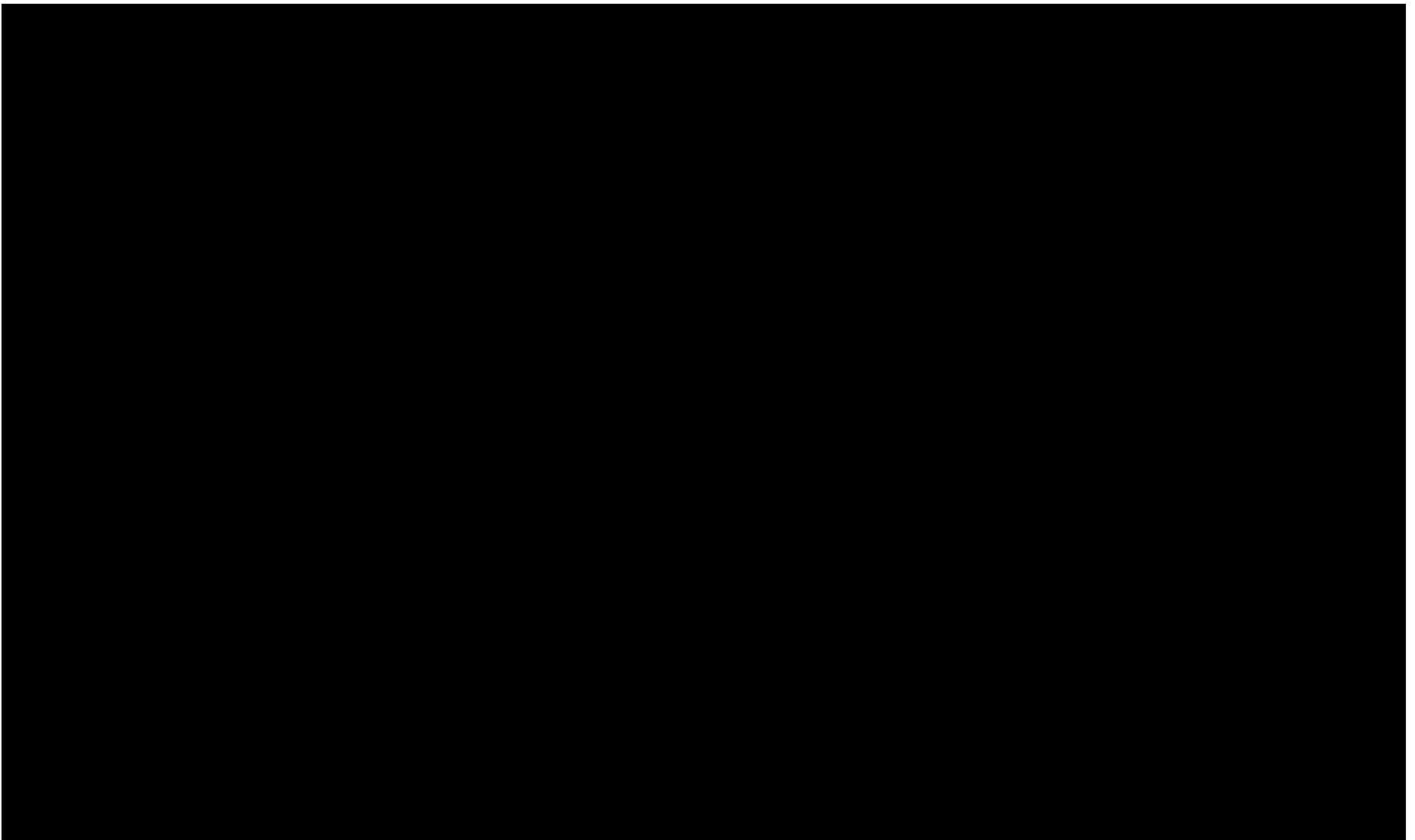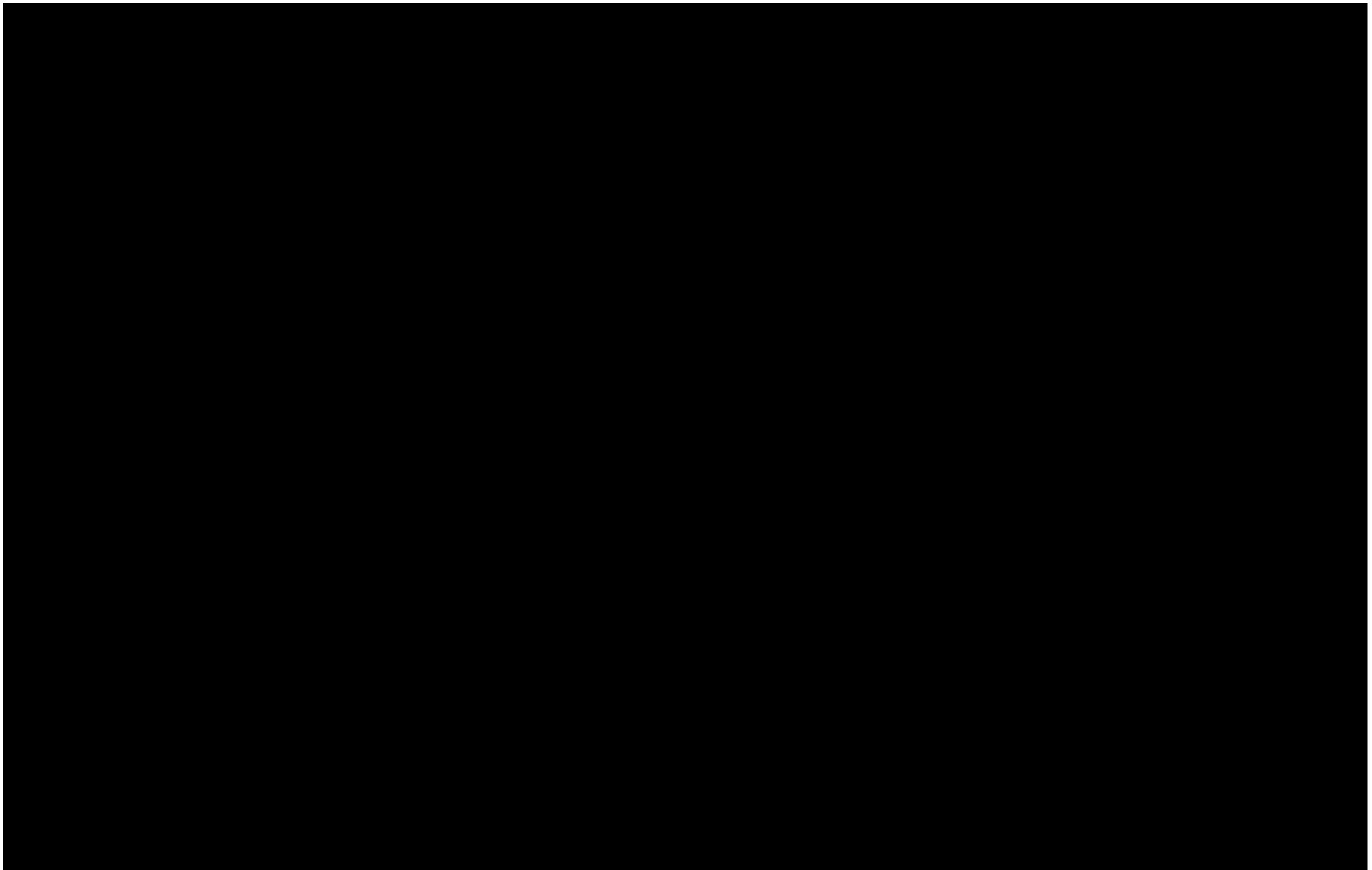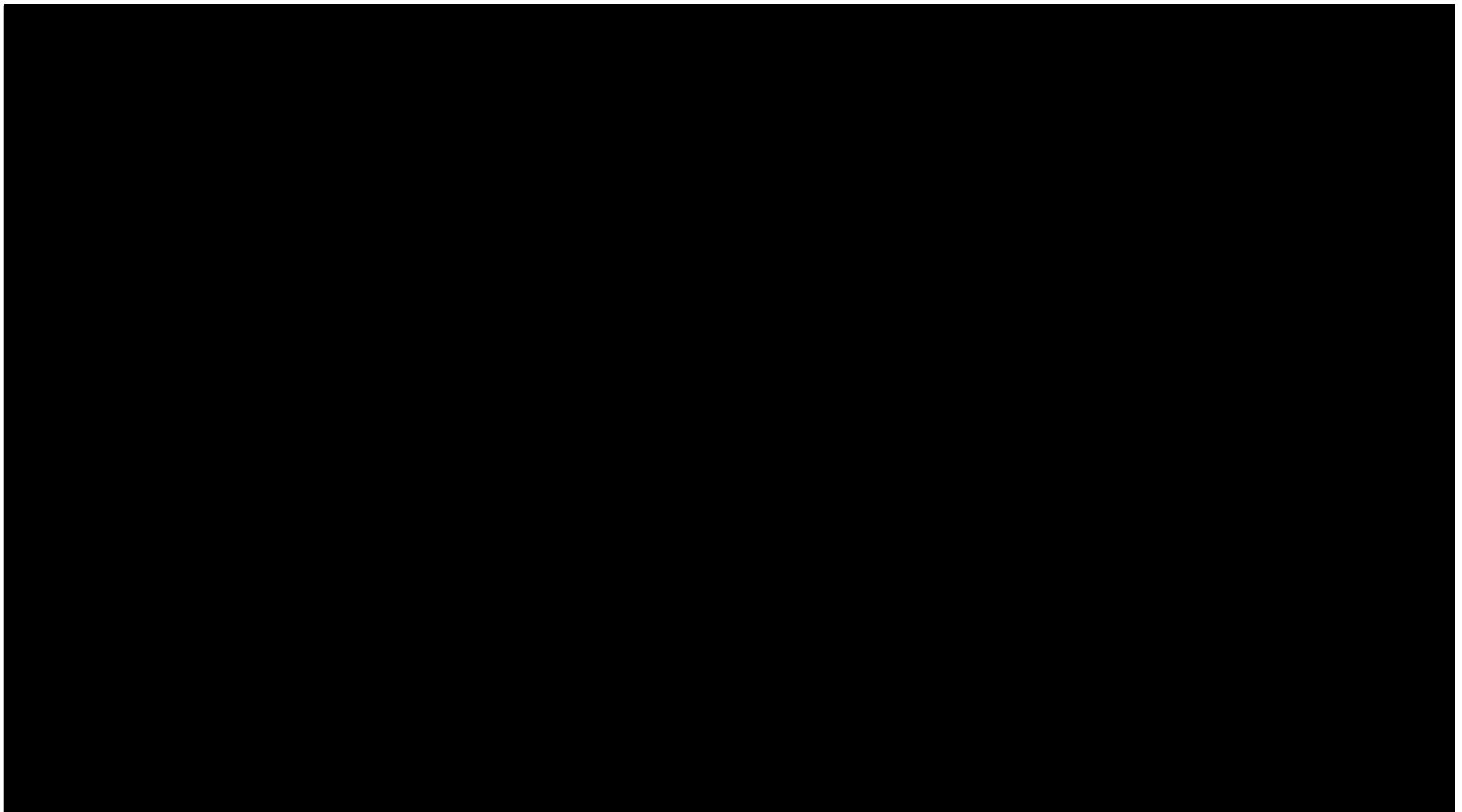
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HIGHLY CONFIDENTIAL – SOURCE CODE

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B. ████████████████████████████

4. ██
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5. ██
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███████████████████████████████████.[71] ████
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██
██████████████████████████

6. █████████████████████████████████[72] ████████
████████████████[73] ████████████████████████
████████████████████[74] ██████████████████████
██████████████

7. ██
████████████████████[75] ████████████████████
██
██████████████████████████

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a) ███████████████████████████████████

████████████ 76 ███████████████████ 77 ██████

d) ████████████████████████████████████

████████ 78 ████████████████████ 79 █████

8. ████████████████████████████████████

███████████████████████████████████████
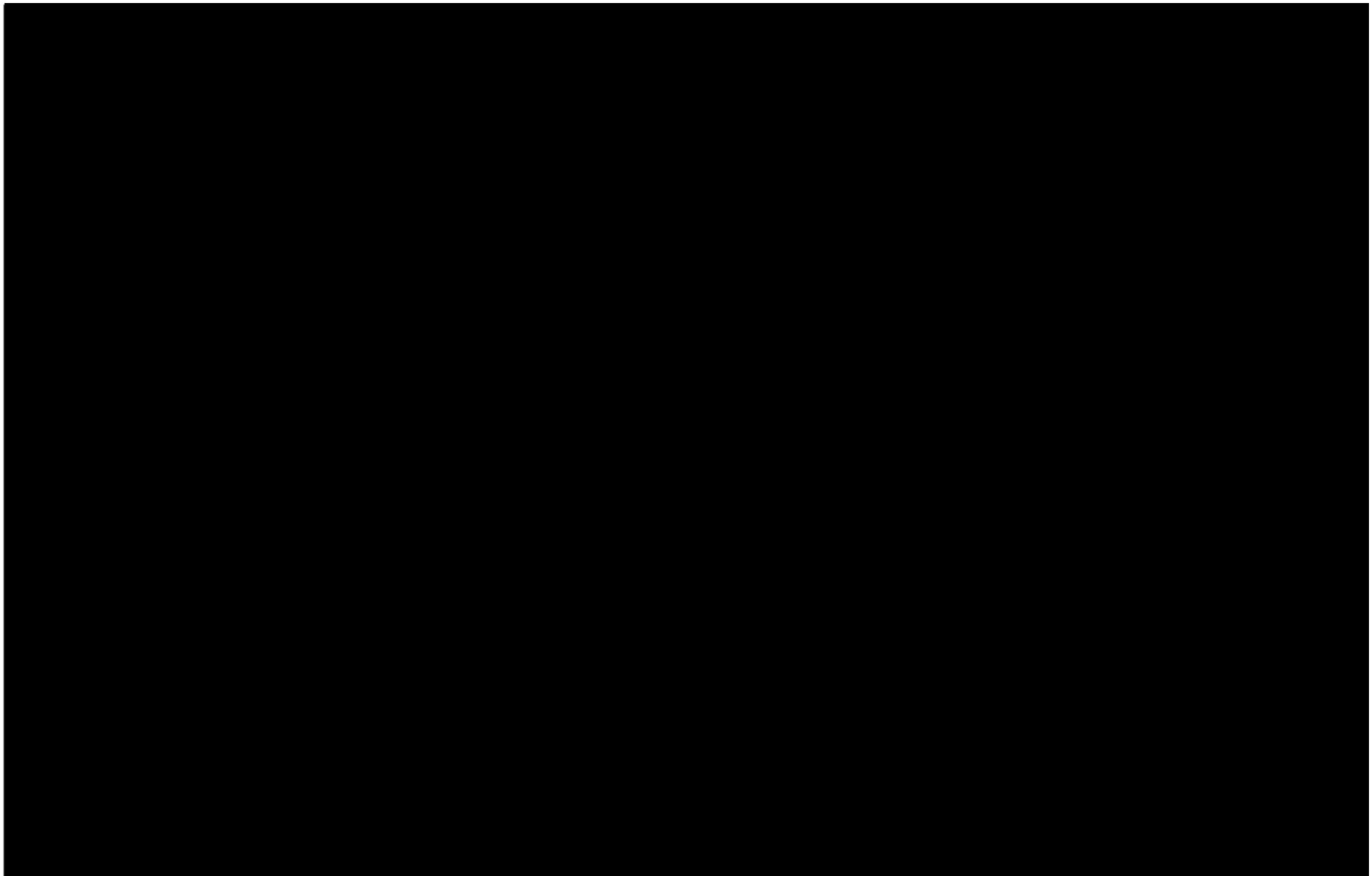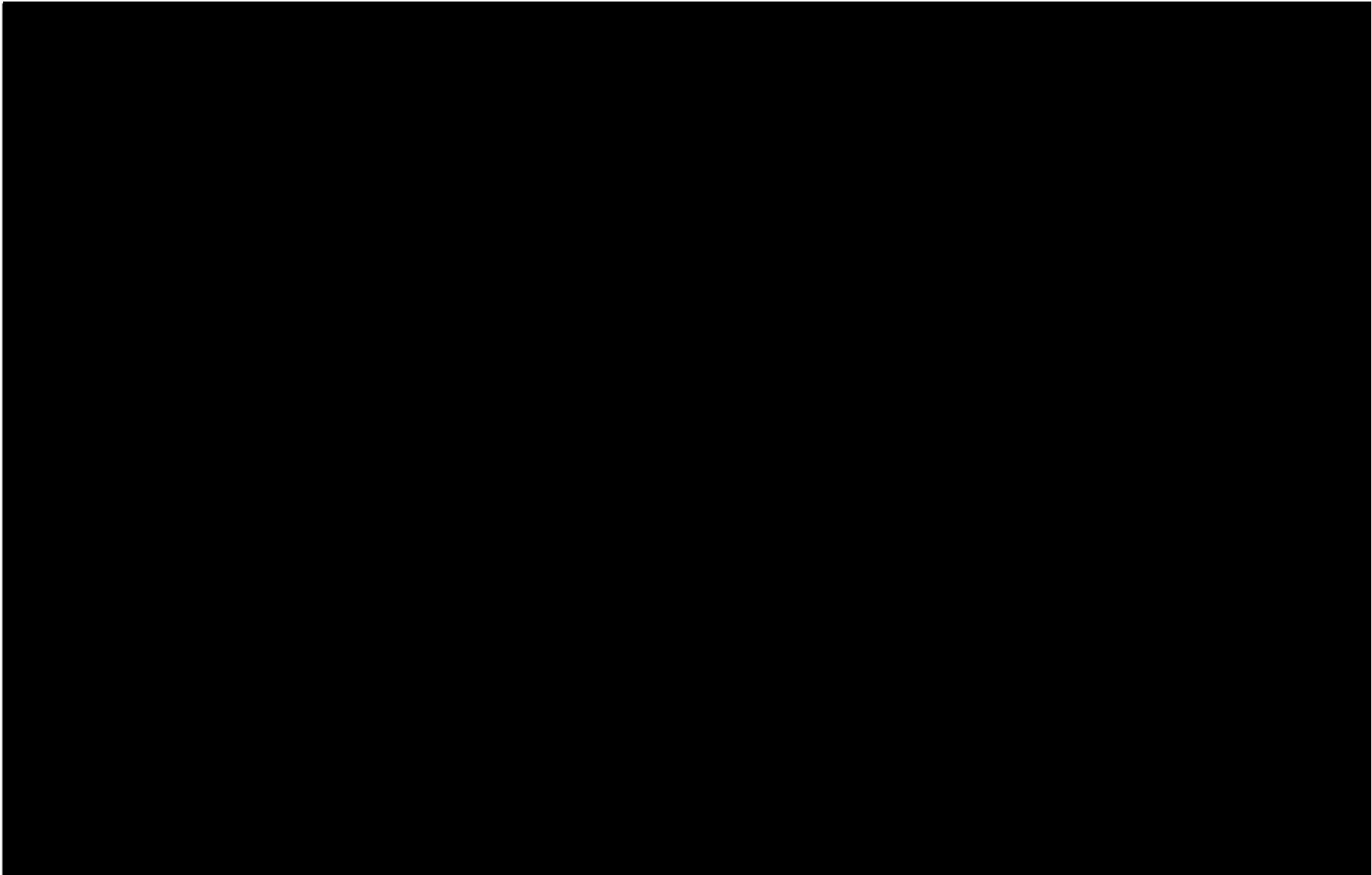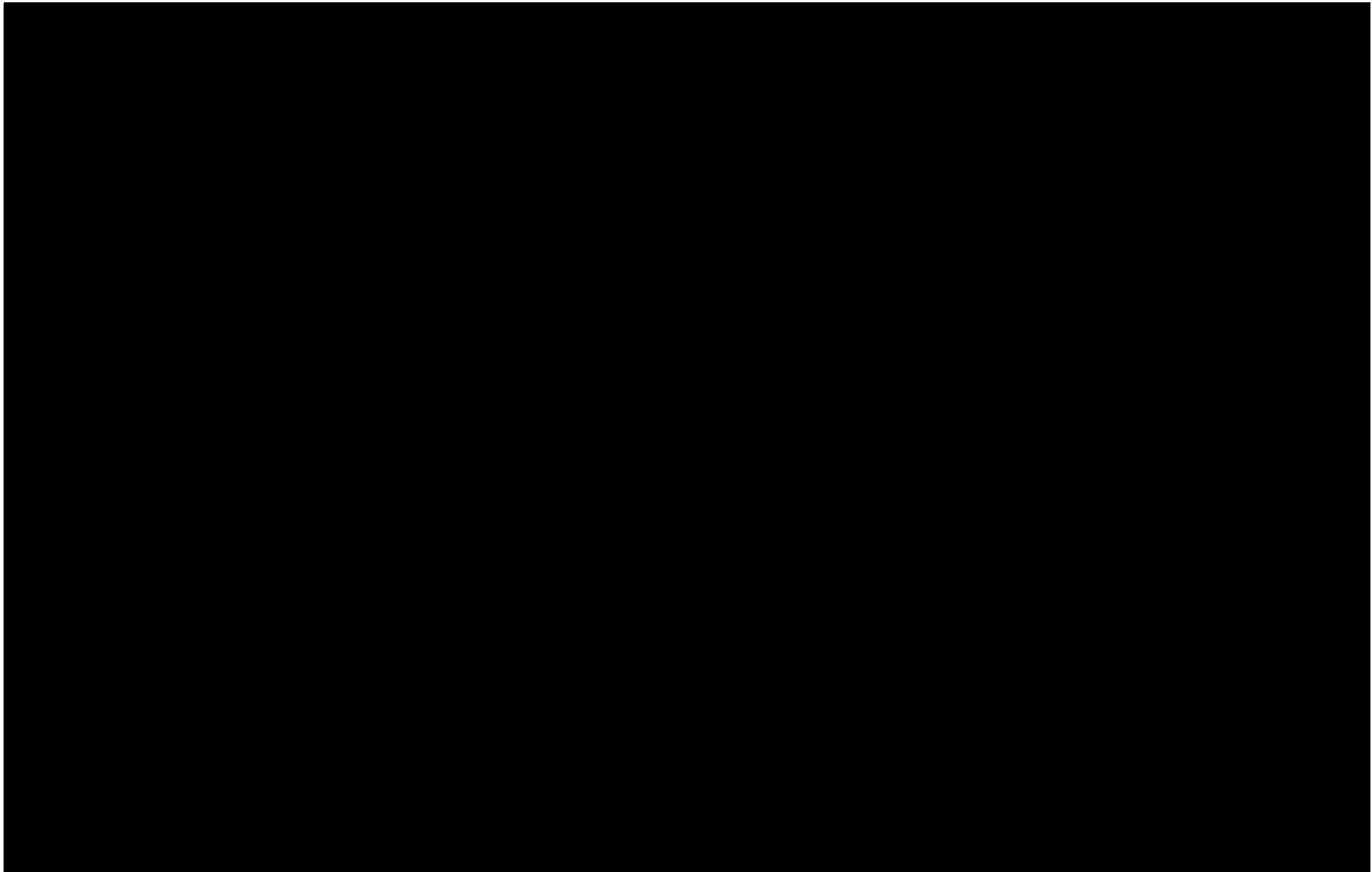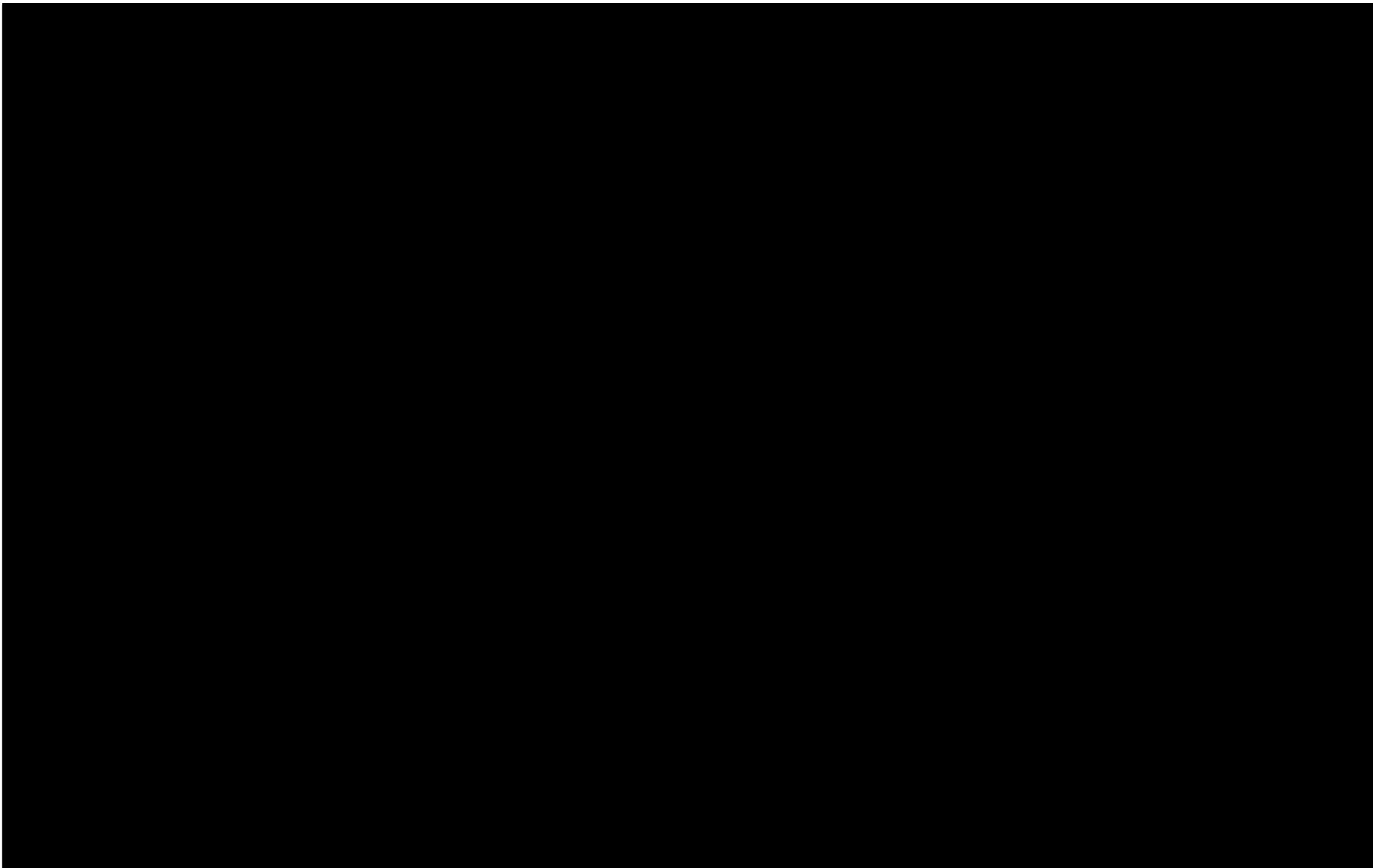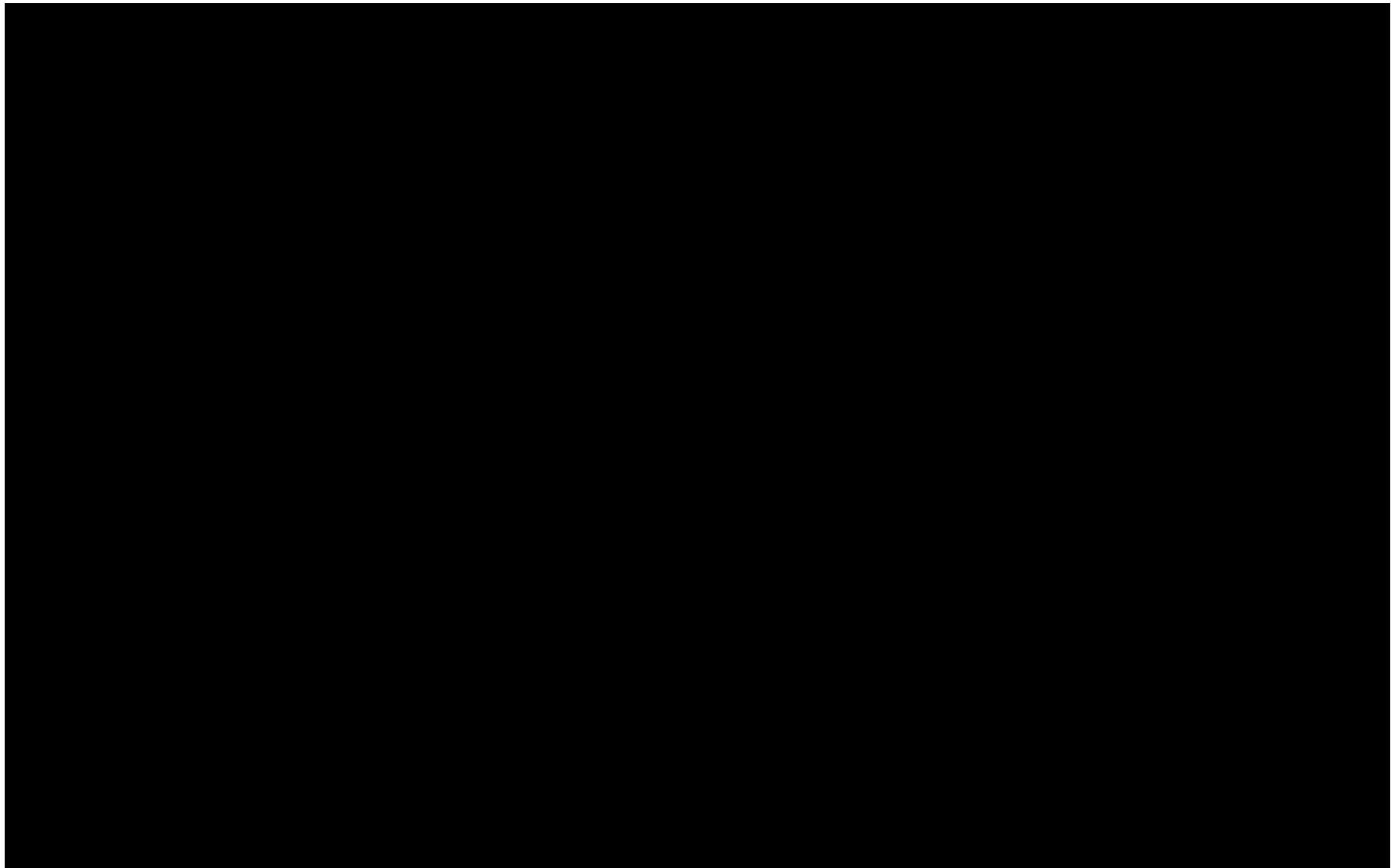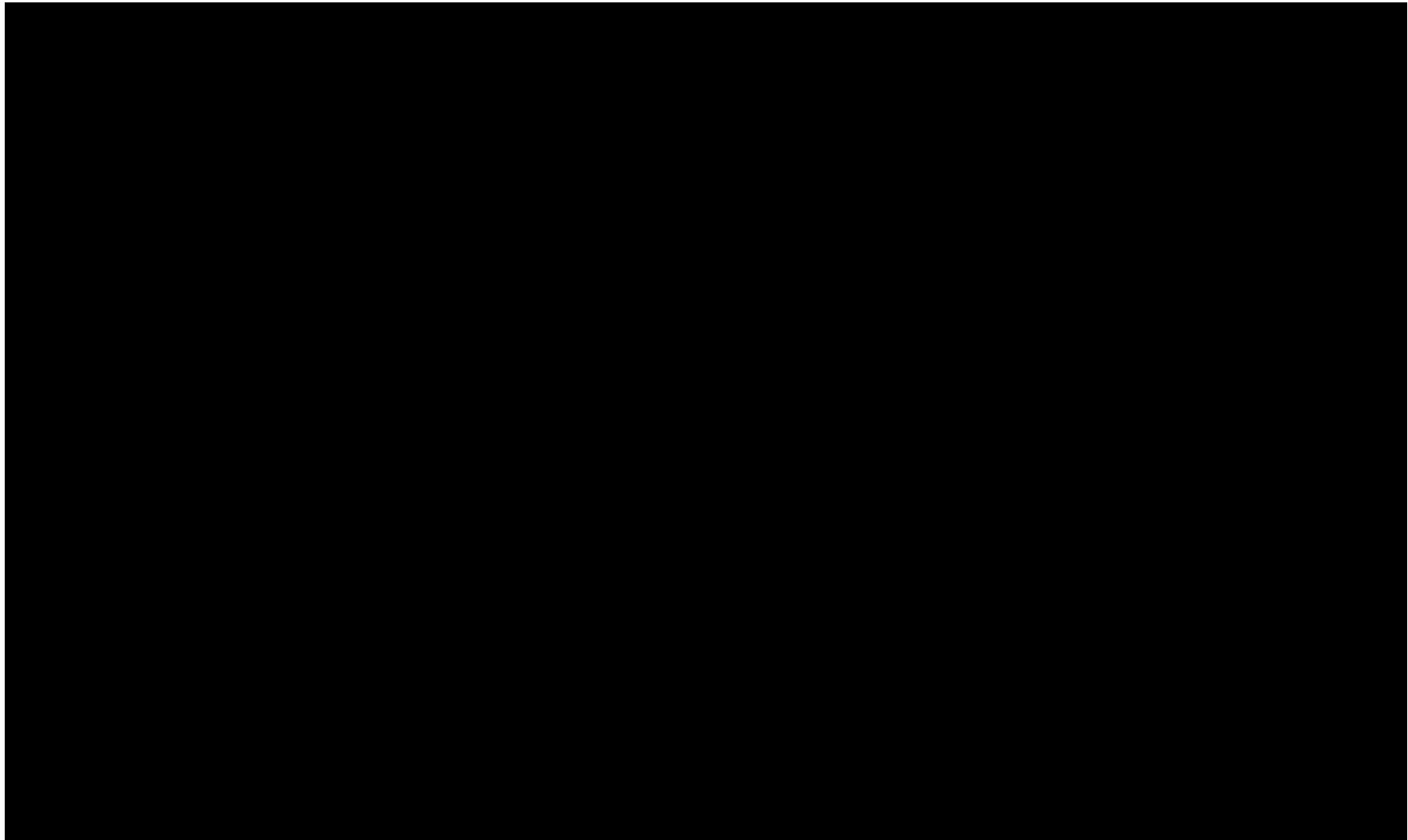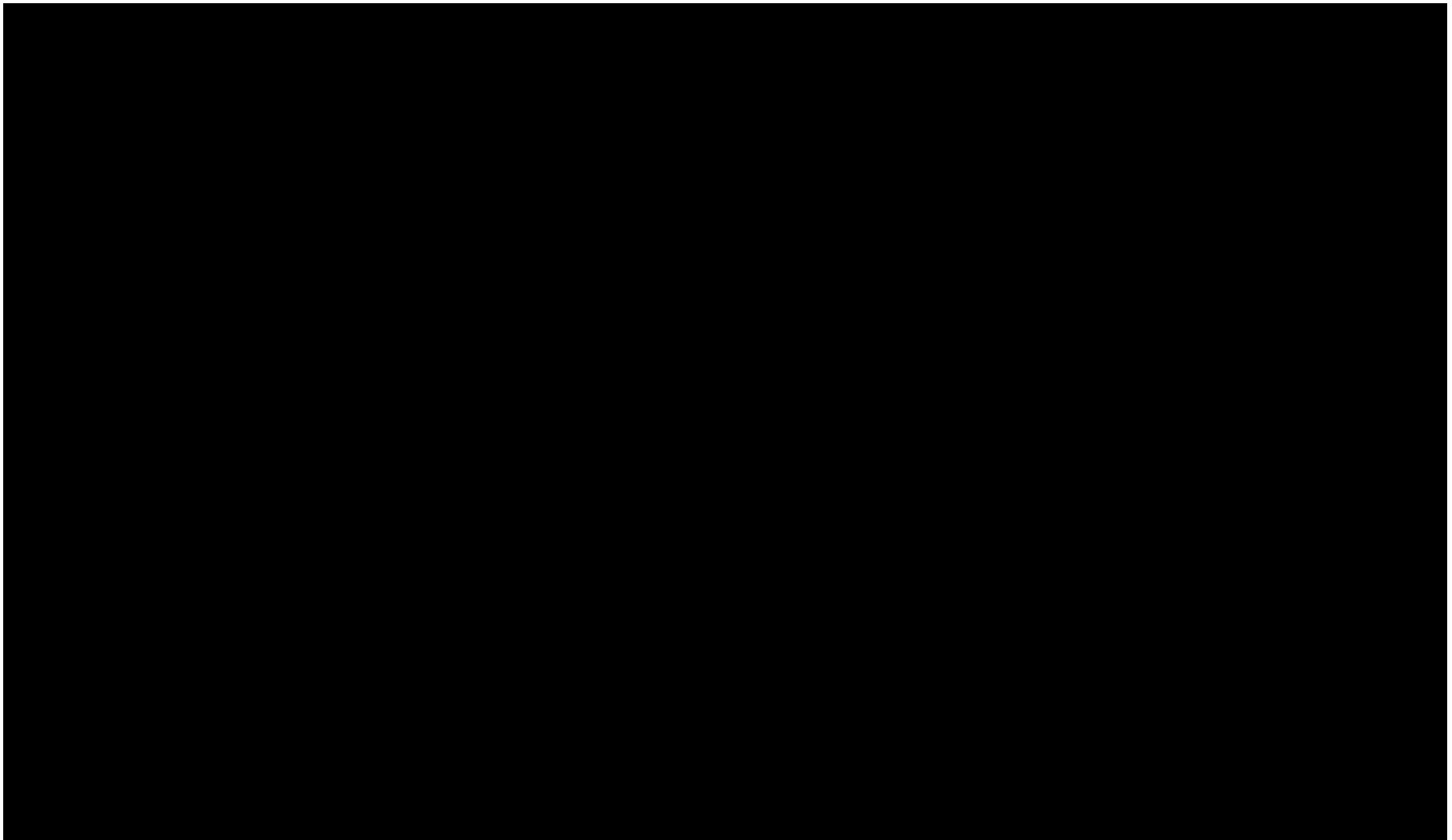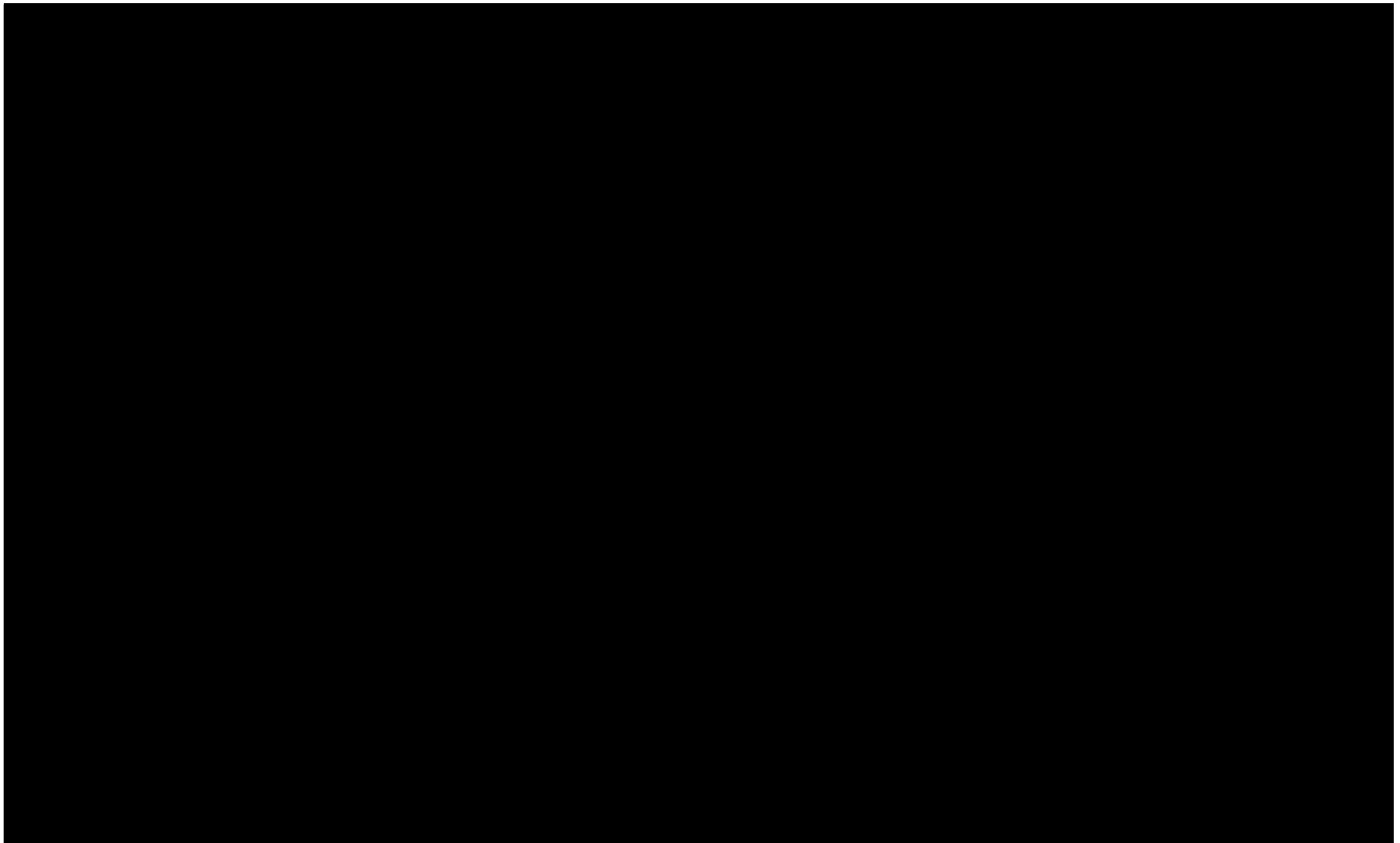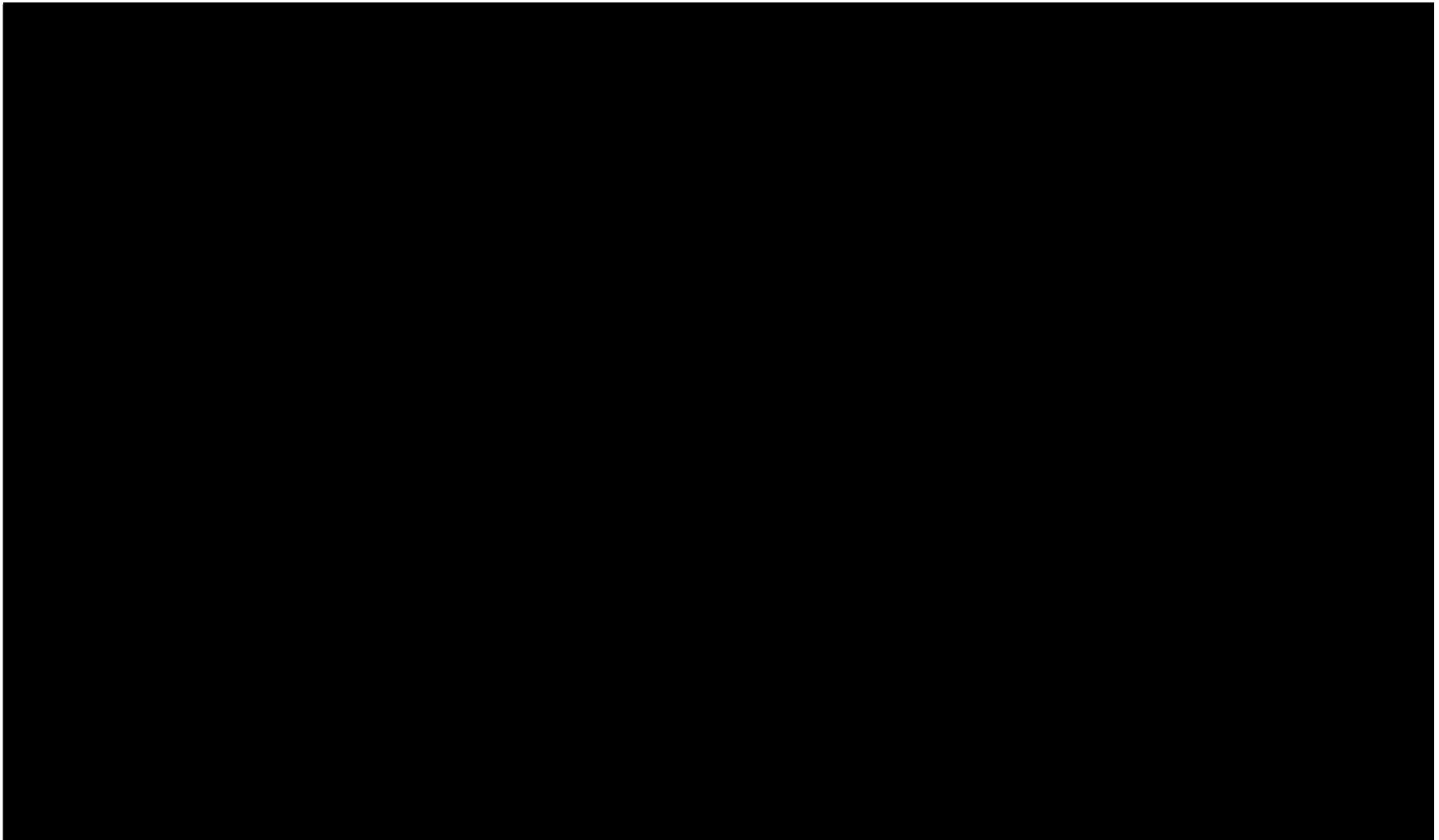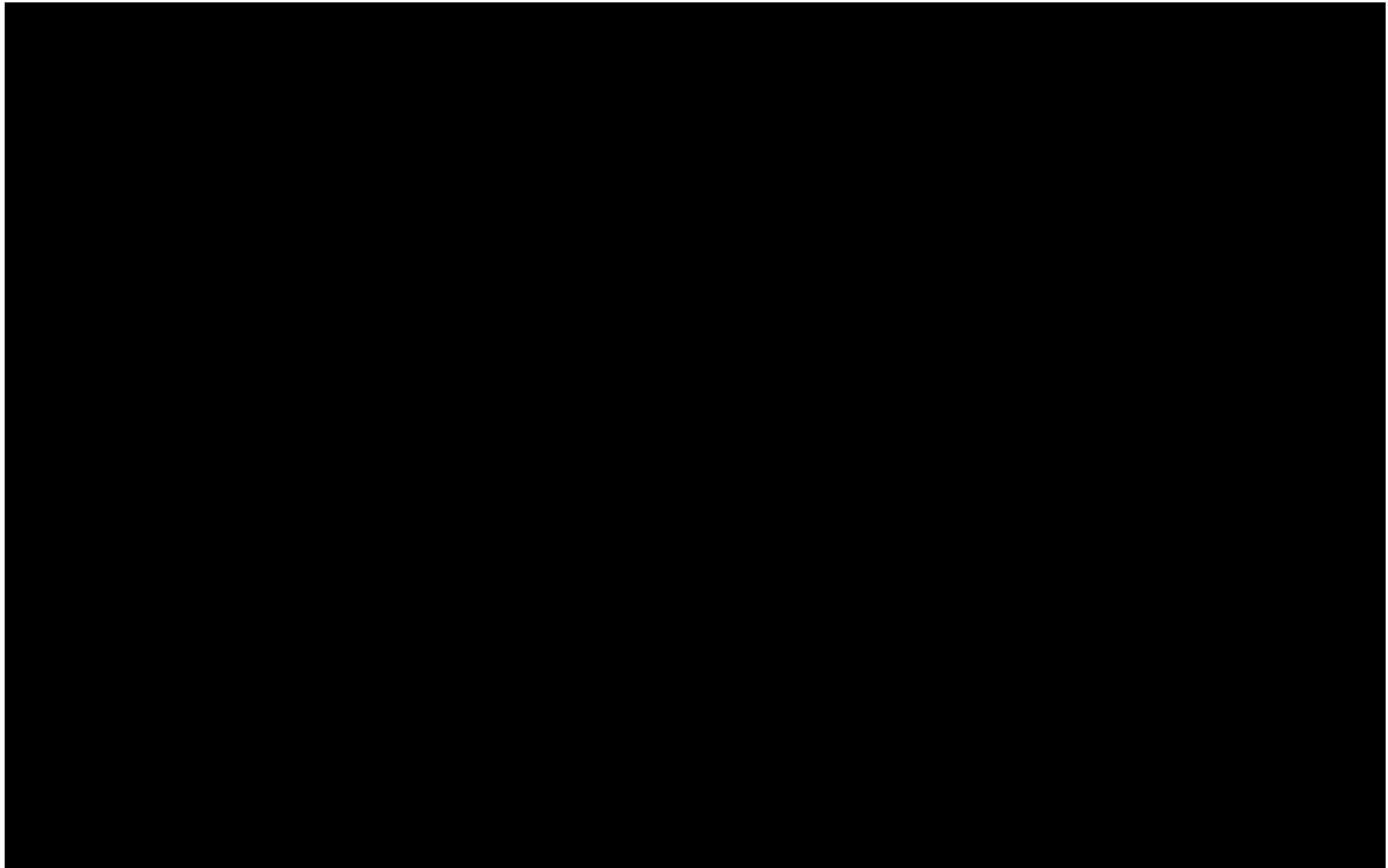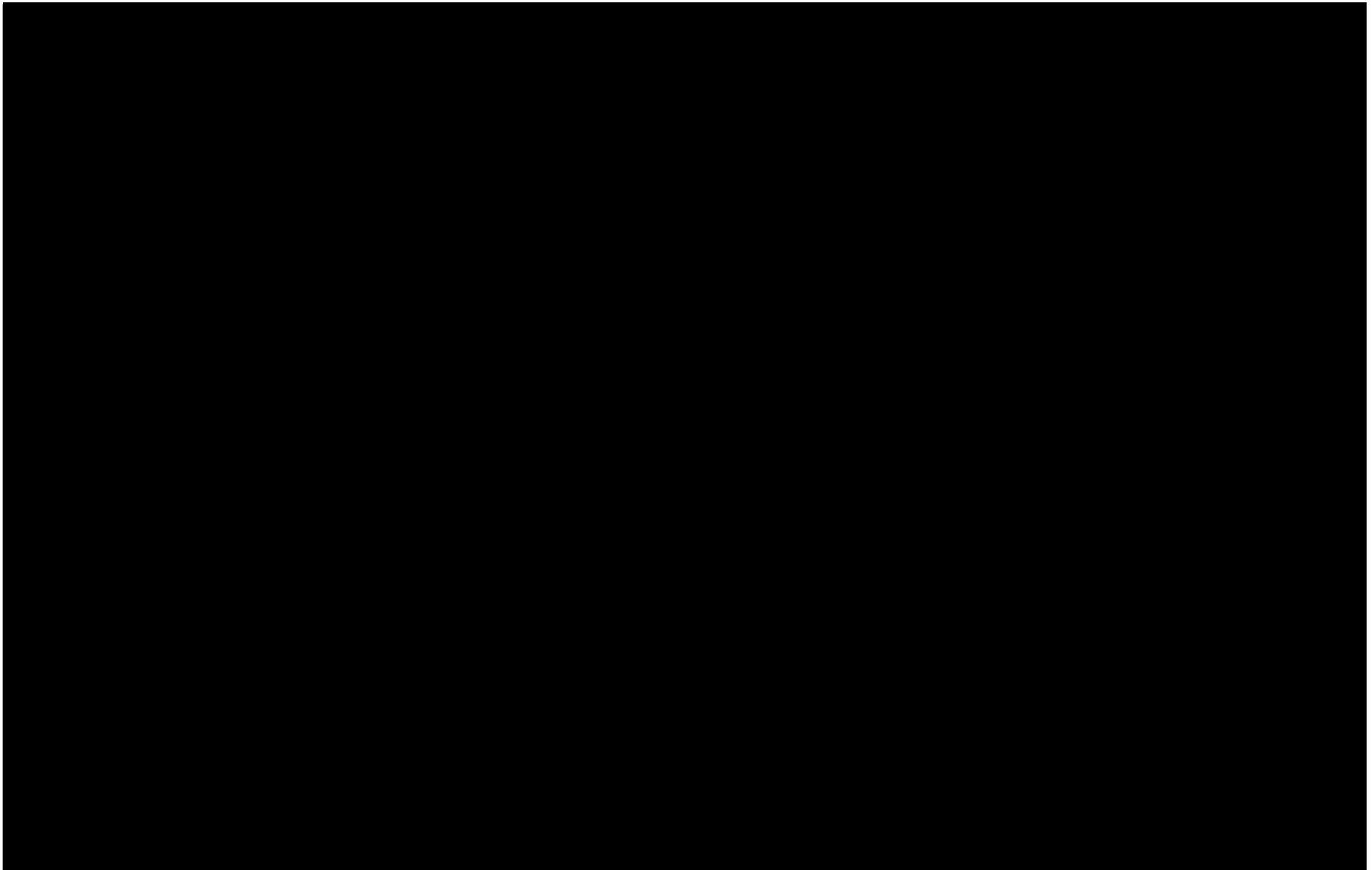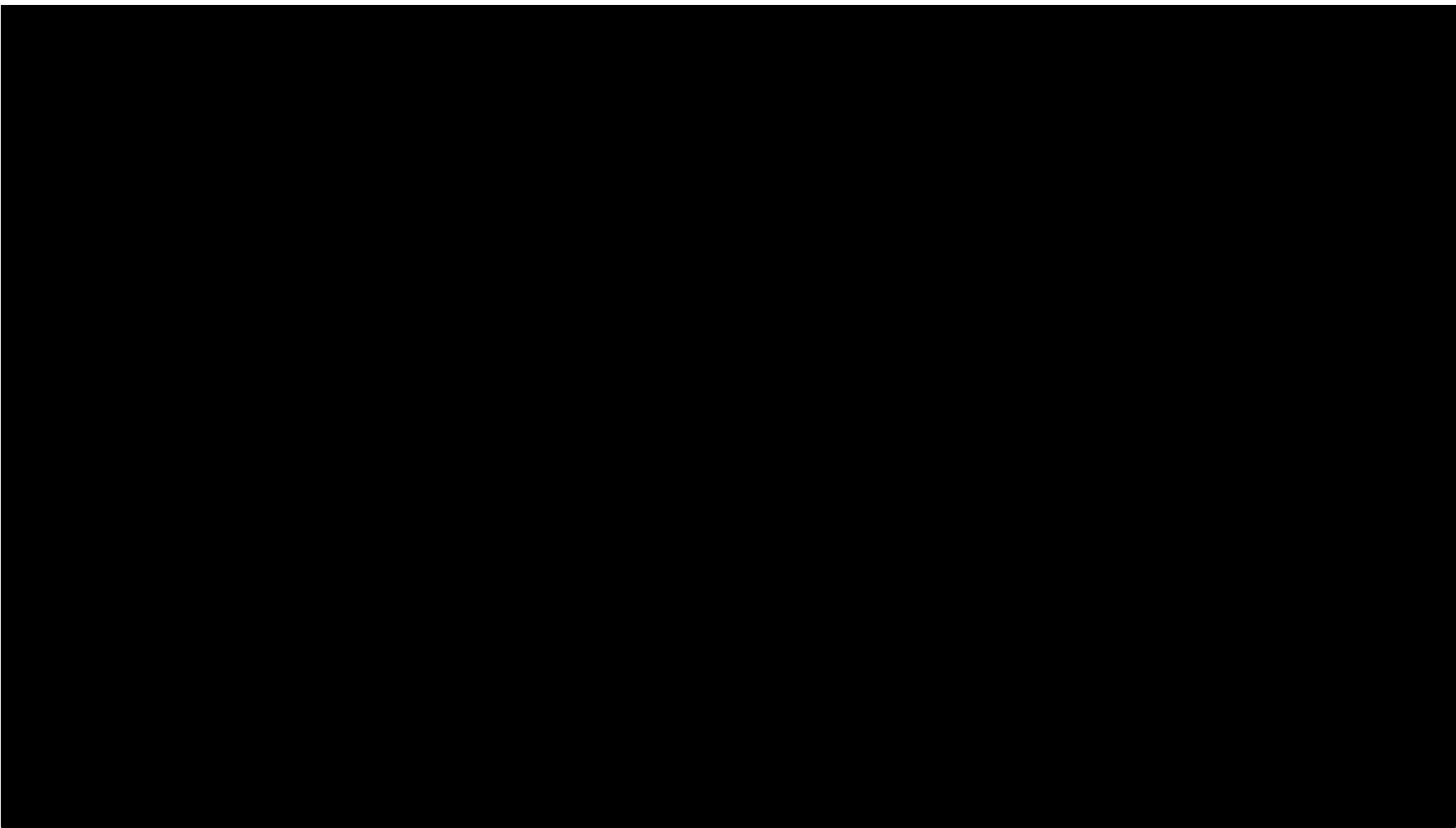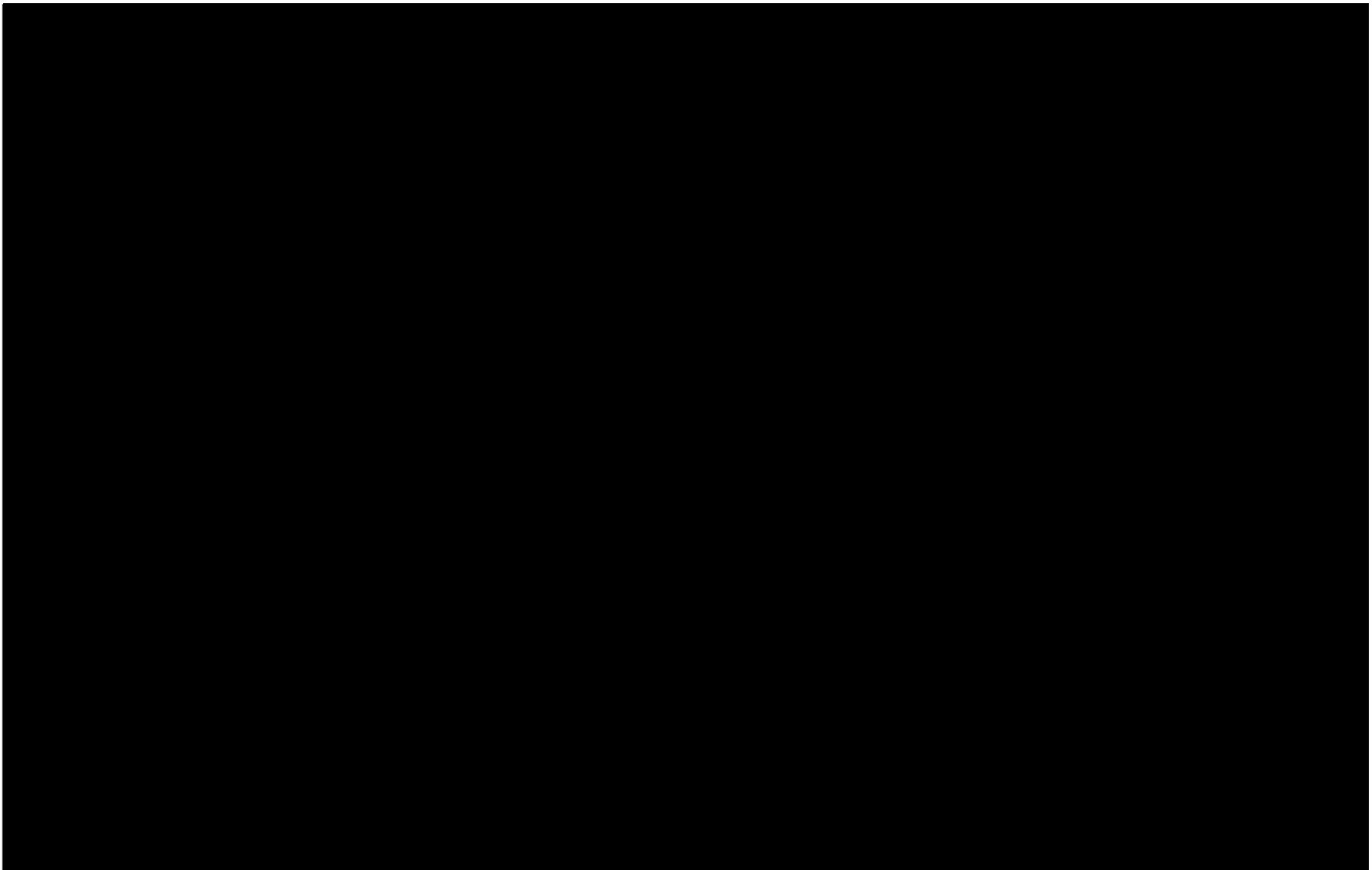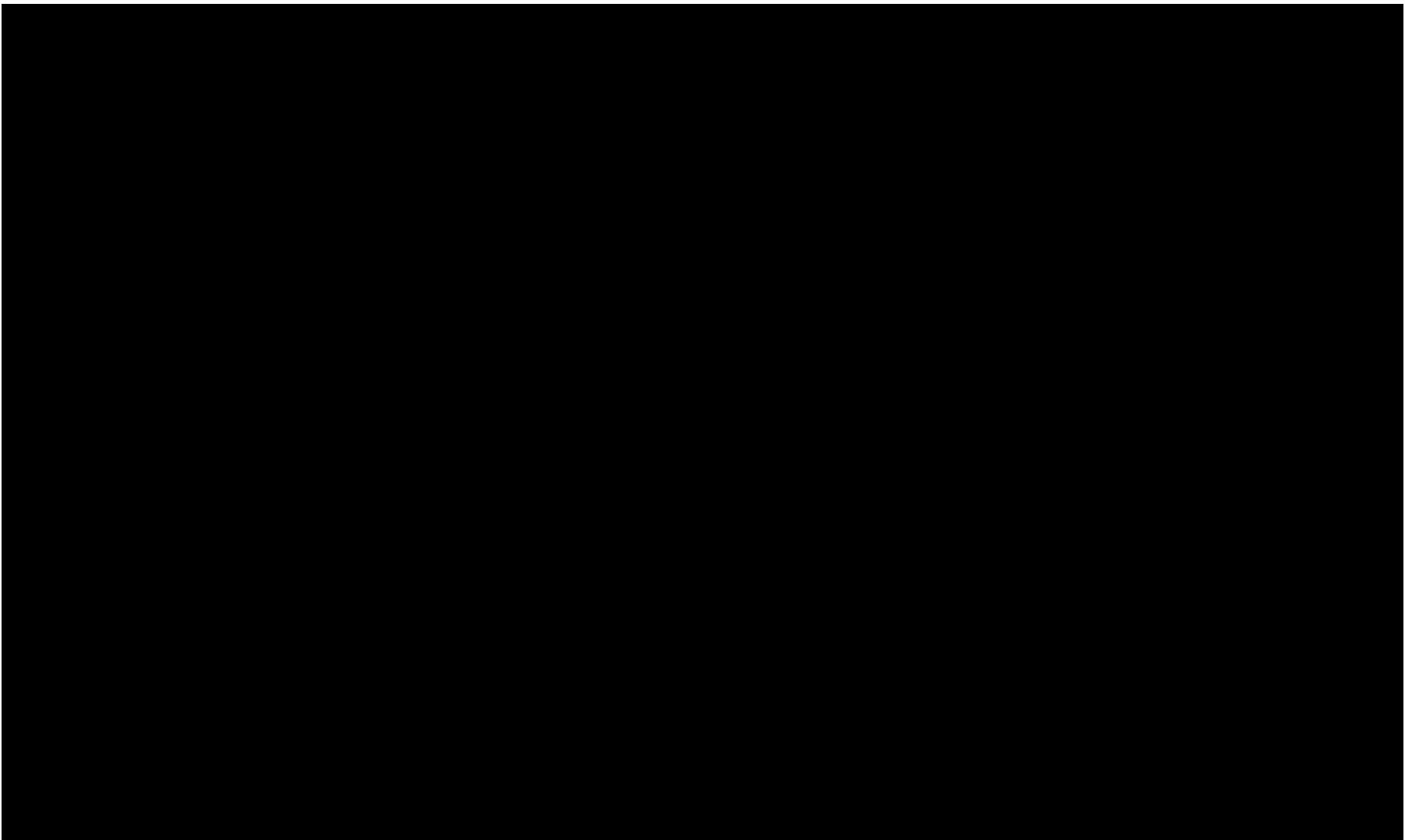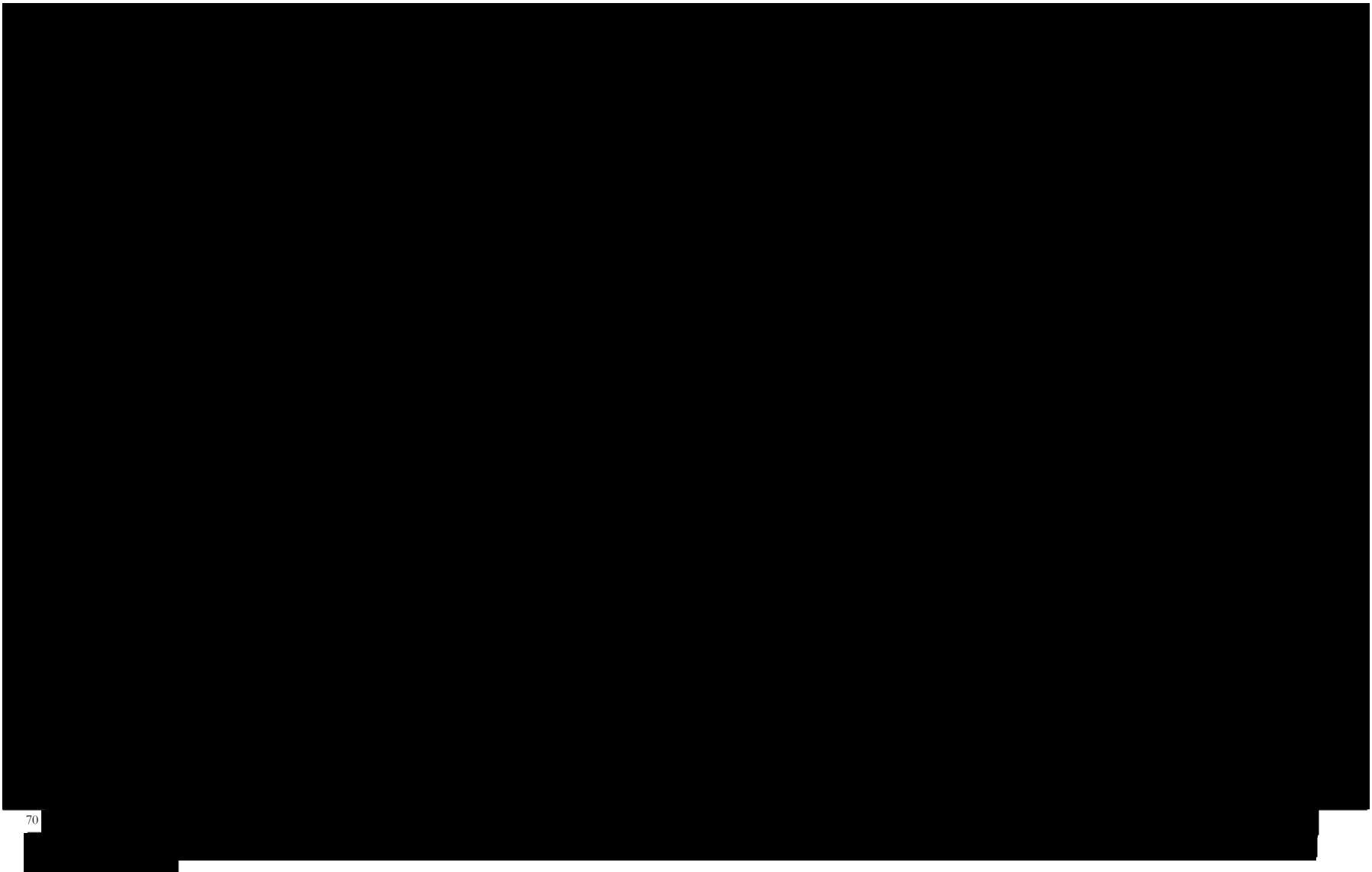
██████████████████ 80 █████████████████████

███████████████████.

9. Figure 3 below illustrates ████████████████████

Figure 3: ████████████████████████████

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10. ████████████████████████████████████

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76 ████████████████████████████████████

77 ████████████████████████████████████

78 ████████████████████████████

79 ███████████████████████████████

80 ████████████████████████████████████

HIGHLY CONFIDENTIAL – SOURCE CODE   80

1) ███████████████████

11. ███

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12. ███████████████████████████████████ ████████████████████

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    a)   ████████████████████████████████████

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2) ████████████████

13. ███

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14. █████████████████████████████████████ █████████[6] ████

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[81] ███████████████████████████████████████

████████████████

[82] ██

[83] ██

[84] ██

[85] ██

[86] ███████████████████████████████

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HIGHLY CONFIDENTIAL – SOURCE CODE   81

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a) ████████████████ ████████████████████████[87] w████████████████████

████████████████████████████████████

b) ██

████████████████ ████████████████████████[88].

c) ██

██ ████████████████████████[89] ████ ████████████████████

████████████████████████████████

████████████████████████[90] ████████████████████

d) ████████████████████████████████

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████████████████████[91]████████

e) ██

████████████████████████[92].

f) ████████████████████████████████████

████████████████ ████████████████[93].

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[87] ██

[88] ██

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[89] ██

[90] ██

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[91] ██

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[92] ██

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[93] ██

HIGHLY CONFIDENTIAL – SOURCE CODE   82

15. ███████████████████████████████████ ████████ [94] ████████

██ [95] ████████████

██████████████ [96] ████████████████████████

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[94] ██

[95] ██

[96] ██

IX.   APPENDIX D: CURRICULUM VITAE OF DR. ANIL SOMAYAJI

[DOCUMENT STARTS ON THE FOLLOWING PAGE]

Anil Somayaji

http://people.scs.carleton.ca/~soma

August 23, 2024

EDUCATION

Ph.D., Computer Science, University of New Mexico, Albuquerque, NM, July 2002. "Operating System Stability and Security through Process Homeostasis."

1999 Complex Systems Summer School (Santa Fe Institute), Santa Fe, NM, June 1999.

Visiting Graduate Student, Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Cambridge, MA, September 1996–June 1997.

B.S., Mathematics, Massachusetts Institute of Technology, Cambridge, MA, 1994.

RECENT EMPLOYMENT

Fall 2003–Present. School of Computer Science, Carleton University, Ottawa, Ontario, Canada. 2003–2008, Assistant Professor; 2008–Present, Associate Professor.

March 2022–May 2024. Consultant for Allens, Australia. (Expert Witness.)

May 2012-Present. Advisor for Zighra, Inc, Ottawa, Ontario, Canada.

November 2016–July 2018. Securelytix, Inc, Wellesley, MA. Chief Scientist. (Early-stage startup, pre-funding/revenue.)

2003–2016. Consultant for Skillbridge Training LLC, Waltham, MA.

Spring 2003. Consultant for Sandia National Laboratories, Albuquerque, NM.

1994–2002. Department of Computer Science, University of New Mexico, Albuquerque, NM. Postdoc, Fall 2002. Research Assistant, 1995–Spring 2002; Teaching Assistant, 1994–1995.

RESEARCH INTERESTS

Computer security, operating systems, systems administration, biologically-inspired computing, complex adaptive systems.

PUBLICATIONS (2014-2024)

Refereed Journal Publications

F.L. Lévesque, S. Chiasson, A. Somayaji, J.M. Fernandez. "Technological and Human Factors of Malware Attacks: A Computer Security Clinical Trial Approach." *ACM Transactions on Privacy and Security (TOPS)*, Vol. 21, Issue 4, Article No. 18 (2018).

S. Sharma, A. Somayaji, N. Japkowicz. "Learning over subconcepts: Strategies for 1-class classification." *Computational Intelligence*, Vol. 34, Issue 2, pp. 440–467 (2018).

Refereed Conference Publications

N. Mansourzadeh, A. Somayaji, J. Jaskolka, "A Fragility Metric for Software Diversity." 19th Annual Symposium on Information Assurance (ASIA'24), Albany, NY (2024).

W. Findlay, A. Somayaji, D. Barrera, "bpfbox: Simple Precise Process Confinement with eBPF." *2020 ACM SIGSAC Conference on Cloud Computing Security Workshop (CCSW)*, Virtual Conference (2020).

N. Dabbour, A. Somayaji, "Towards In-Band Non-Cryptographic Authentication." *2020 New Security Paradigms Workshop (NSPW)*, Virtual Conference (2020).

M. Burgess, A. Somayaji. "After the BlockCloud Apocalypse." *2018 New Security Paradigms Workshop (NSPW)*, Windsor, UK (2018).

B. Obada-Obieh, A. Somayaji, "Can I believe you?: Establishing Trust in Computer Mediated Introductions." *2017 New Security Paradigms Workshop (NSPW)*, Santa Cruz, CA USA (2017).

B. Obada-Obieh, S. Chiasson, and A. Somayaji, ""Don't Break My Heart!": User Security Strategies for Online Dating." *Workshop on Usable Security (USEC)*, San Diego, CA USA (2017).

F.L. Lévesque, J.M. Fernandez, A. Somayaji, and D. Batchelder, "National-level risk assessment: A multi-country study of malware infections." *15th Annual Workshop on the Economics of Information Security (WEIS)*, Berkeley, CA USA (2016).

F.L. Lévesque, A. Somayaji, d. Batchelder, J.M. Fernandez, "Measuring the health of antivirus ecosystems." *10th International Conference on Malicious and Unwanted Software (MALWARE)*, Puerto Rico, USA (2015).

F.L. Lévesque, J.M. Fernandez, A. Somayaji, "Risk Prediction of Malware Victimization Based on User Behavior." *9th International Conference on Malicious and Unwanted Software: The Americas (MALWARE)*, Puerto Rico, USA (2014).

T. Moni, S. Salahudeen, A. Somayaji, "The Malware Author Testing Challenge." *Second Workshop on Anti-malware Testing Research (WATeR)*, Canterbury, UK (2014).

M. Bingham, A. Skillen, and A. Somayaji, "Even Hackers Deserve Usability: An Expert Evaluation of Penetration Testing Tools." *9th Annual Symposium on Information Assurance (ASIA'14)*, Albany, NY (2014).

J. Aycock, A. Somayaji, and J. Sullins, "The Ethics of Coexistence: Can I Learn to Stop Worrying and Love the Logic Bomb?" *2014 IEEE International Symposium on Ethics in Engineering, Science, and Technology*, Chicago, IL (2014).

Invited Publications

B. Persaud, B. Obada-Obieh, N. Mansourzadeh, A. Moni, and A. Somayaji. "FrankenSSL: Recombining Cryptographic Libraries for Software Diversity." *11th Annual Symposium on Information Assurance (ASIA'16)*, Albany, NY (2016).

Patents

DC Dutt, AB Somayaji, MJK Bingham. "System and method for behavioural biometric authentication using program modelling." US Patent 10,554,676 (2020).

DC Dutt, AB Somayaji, MJK Bingham. "System and method for implicit authentication." US Patent 10,588,017 (2017, 2019, 2020).

DC Dutt, AB Somayaji. "Context-dependent authentication system, method and device." US Patent 10,740,758 (2017, 2020).

CE Gates, TG Brown, A Somayaji, and Y Li. "System and method for dynamic access control based on individual and community usage patterns." US Patent 9,356,939 (2016).

Technical Reports

W. Findlay, D. Barrera, and A. Somayaji. "Bpfcontain: Fixing the soft underbelly of container security." arXiv preprint arXiv:2102.06972 (2021).

RESEARCH GRANTS

Year	Agency	Type	Amount per year
2014-19	NSERC	Discovery	$32,000
2013-2015	NSERC/ISTP	CRD (Zighra)	$112,500 (avg.)
2013	NSERC	Engage (Zighra)	$24,967
2009-14	NSERC	Discovery	$19,000
2008-13	NSERC	ISSNet	$63,160 (avg.)
2011	MITACS, CA	Internship Cluster	$80,000
2009	CSE	Research Grant	$23,810
2008	Swisscom	Research Grant	$15,000
2007-9	MITACS	Comm., Net., & Security	$33,750 (joint w/ Paul van Oorschot)
2007-9	NSERC	Discovery	$19,700

2006-9	RIM	Research Grant	$50,000 (joint w/ Paul van Oorschot)
2006	CSE	Research Grant	$23,128 (joint w/ Paul van Oorschot)
2005-7	MITACS	Comm., Net., & Security	$33,750 (joint w/ Paul van Oorschot)
2004	Alcatel	Research Grant	$50,000 (joint w/ Paul van Oorschot)
2004-7	NSERC	Discovery	$19,700
2003	Carleton	Start-up	$20,000

PROFESSIONAL SERVICE

New Security Paradigms Workshop (NSPW): Program Committee member (1998, 1999, 2007, 2019), Web Presence Chair (2010–2023), Senior Program Chair (2009, 2018), Junior Program Chair (2008, 2017), General Chair (2015), Vice General Chair (2014).

ACM Cloud Computing Security Workshop (CCSW): Program Committee member, 2020, 2021, 2022.

Recent Advances in Intrusion Detection (RAID): Program Committee member, 2009–2014.

Privacy, Security and Trust (PST): Program Committee member, 2008, 2012, 2013.

Applied Cryptography and Network Security (ACNS): Program Committee member, 2013.

ACM Conference on Computer and Communications Security (CCS): Program Committee member, 2008, 2010, 2011, 2012.

Annual Computer Security Apps Conference (ACSAC): Program Committee member, 2010, 2011, 2012.

2012 Financial Cryptography and Data Security (FC): Program Committee member.

2010 Workshop on Cyber Security Experimentation and Test (CSET): Program Committee member.

2009 IEEE Conference on Malicious and Unwanted Software (MALWARE): Program Committee member.

USENIX Security Symposium: Program Committee member, 2006, 2008.

2008 International Conference on Information Systems Security (ICISS): Program Committee member.

2008 ICCCN Network Security Track: Program Committee member.

2008 IEEE Conference on Malicious and Unwanted Software (MALWARE): Program Committee member.

2007 Workshop on Rapid Malcode (WORM): Program Committee member.

2007 International Conference on Distributed Computing Systems (ICDCS): Program Committee member.

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2006 Workshop on Interdisciplinary Systems Approach in Performance Evaluation and Design of Computer and Communication Systems (Inter-Perf): Program Committee member.

ACADEMIC RESPONSIBILITIES

Courses

COMP 2601, Mobile Applications: Winter 2023.

COMP 4000/5102, Distributed Operating Systems: Winter 2008, Fall 2008, Winter 2011, Winter 2014, Winter 2015, Fall 2017, Fall 2018, Fall 2019, Fall 2021, Winter 2023. Revived course.

COMP 3000, Operating Systems: Fall 2004, Fall 2005, Winter 2006, Winter 2007, Fall 2007, Fall 2010, Fall 2011, Fall 2012, Fall 2014, Fall 2015, Fall 2017, Fall 2018, Winter 2019, Fall 2019, Winter 2020, Fall 2021, Fall 2022. Revised course curriculum, added mandatory lab tutorials.

COMP 1601, Mobile App Development: Winter 2021, Winter 2022.

COMP 4501, Advanced Facilities for Real-Time Games: Winter 2021.

Adaptive Security: Fall 2020. New course.

COMP 4108, Computer Systems Security: Winter 2016, Winter 2018.

COMP 2406, Fundamentals of Web Apps: Winter 2013, Fall 2013, Winter 2014, Winter 2015, Winter 2016. New course.

Operating Systems and Web Security: Fall 2012. New course.

COMP 1501, Introduction to Computer Game Design: Fall 2007, Fall 2008 (co-taught with Prof. Michel Barbeau), Winter 2012. New course, first course in new Computer Game Design stream.

Intrusion Detection: Winter 2006, Winter 2007, Winter 2011. New course.

Biological Approaches to Computer Security: Winter 2004, Winter 2005, Winter 2012. New course.

COMP 4109, Applied Cryptography: Winter 2004, Winter 2005.

Completed Graduate Supervision

Emma Sewell, MCS (co-advised with Lianying Zhao), August 2023. "Hy2: A Hybrid Vulnerability Analysis Method."

John Shortt, MCS (co-advised with Amy Felty), January 2023. "A System for Bounding the Execution Cost of WebAssembly Functions."

William Findlay, MCS, August 2021. "A Practical, Lightweight, and Flexible Confinement Framework in eBPF."

Anis Ghazvinian, MASc (HCI), January 2020. "Understanding User Trust Processes in Internet Apps."

Vidhi Kirit Shah, MCS, January 2020. "User Acceptance of Online Tracking If 'Forgetting' Was An Option."

Mohamed Alsharnouby, MCS, September 2019. "Thread homeostasis Real-Time Anomalous Behavior Detection Using Short Sequences of Messages for Safety-Critical Software."

Nour Dabbour, MASc (HCI), May 2019. "Do I know you? Evaluating Human-to-Human Authentication via Conversational Interfaces."

Borke Obada-Obieh, MCS, September 2017. "The Issue of Trust in Computer Mediated Introductions (CMI)."

Michael Bingham, MCS, May 2016. "Towards Effective Behavioural Biometrics for Mobile Devices."

Shiven Sharma, Ph.D. (co-advised with Nathalie Japkowicz), May 2016. "Learning the Sub-Conceptual Layer: A Framework for One-Class Classification."

Abdulrahman Hijazi, Ph.D., January 2014. "Network Traffic Characterization Using (p,n)-grams Packet Representation."

Saran Neti Maruti Ramanarayana, MCS, September 2012. "Towards a Theory of Software Diversity for Security."

Terri Oda, Ph.D., October 2011. "Simple Security Policy for the Web."

Alex Cowperthwaite, MCS, September 2011. "Trust Models for Remote Hosts."

Gunes Kayacik, Postdoc, Sept. 2009–August 2011.

Blair Foster, MCS, June 2011. "Object File Program Recombination of Existing Software Programs Using Genetic Algorithms."

Carson Brown, MCS (co-advised with Paul van Oorschot), February 2011. "A Meta-Scheme for Authentication Using Text Adventures."

Preeti Raman, MCS, September 2008. "JaSPIn: JavaScript based Anomaly Detection of Cross-site Scripting Attacks."

Evan Hughes, MCS, September 2006. "Parsing Streaming Network Protocols."

Yiru Li, MCS, November 2005. "Email Archive Intrusion Detection."

Current Graduate Students

Heather Farrar, MCS student, since September 2019.

William Findlay, Ph.D. student (co-supervised with David Barrera), since September 2021.

Nilofar Mansourzadeh, Ph.D. student, since January 2016.

Emma Sewell, MCS student (co-supervised with Lianying Zhao), since September 2021.

John Shortt, MCS student (co-supervised with Amy Felty), since March 2021.

Evelyn Yang, MCS student, since September 2021.

ADMINISTRATIVE RESPONSIBILITIES

Sabbatical, 2009–2010, 2016–2017, 2023-2024.

SCS Representative, SCAP (Science Curriculum Advisory Committee), 2017–2023.

Chair, SCS Faculty Search Committee (Security), 2018–2019.

Chair, SCS Faculty Search Committee (Systems), 2017–2018.

Member, SCS Faculty Search Committee, 2004–2005, 2005–2006, 2006–2007, 2007–2008, 2010–2011, 2015–2016.

Member, SCS Curriculum Committee, 2014–2015.

Chair, SCS Curriculum Reinvention Committee, 2009–2014.

Chair, SCS Curriculum Committee, 2010–2011.

SCS Honours Project Coordinator, 2005–2007.

Secretary, SCS Tenure and Promotion Committee, 2005–2006.

Member, SCS Tenure and Promotion Committee, 2004–2005, 2011–2012.

Member, SCS Director Search Committee, 2005–2006 and 2007–2008.

School of Computer Science CUASA representative, 2005–2006.

EXPERT TESTIMONY

Epic Games, Inc. & Anor v. Google LLC & Ors (NSD190/2021) (Reports, Deposition, Trial testimony)

Epic Games, Inc. & Anor v. Apple Inc. & Anor (NSD1236/2020) (Reports, Deposition, Trial testimony)